Bridging the Gap:
Funding Sea Level Rise Adaptation in the Bay Area

December 2021

Photo by Kyle Cottrell on Unsplash

Contents

Executive Summary

Rising sea levels (SLR) will have widespread impacts on the Bay Area, and adapting to this hazard will cost tens of billions of dollars over the next several decades. This paper is an initial exploration of forecasted estimated damages in the absence of adaptation, as well as the funding needs, funding supplies, and funding gaps that the region could face as it adapts to rising sea levels during this century. It is apparent that multiple funding sources – a diverse set of public funding mechanisms as well as private and philanthropic funding – will be required for the Bay Area to adequately address this problem.

This exploration is based on what we know now. But, there is so much uncertainty surrounding the "how," "when," and "where" of SLR that this exploration needs to be viewed against the kaleidoscope of so many issues that are based on forecasts that, themselves, can be viewed as uncertain.

3. USGS[2] economic property damage estimates caused by around 3' of SLR with a 1-year storm in the Bay Area is $55.8 billion, which is comparable to Superstorm Sandy at $55.6 billion. The estimate resulting from about 6' of SLR with a 1-year storm in the Bay Area is $118.8 billion, putting it in the ballpark of Hurricane Katrina at $144 billion.
4. Regional costs for adapting to 2' of SLR are around $19 billion (Metropolitan Transportation Commission/Association of Bay Area Governments), while adapting to 6' of SLR could cost around $146 billion (UC Berkeley).
5. This paper projects a hypothetical funding supply range of between $63.7 million and $318.5 million per year that may be allocated or raised for Bay Area SLR adaptation efforts based on recent city expenditure and revenue data collected by the State Controller's Office (SCO).

"The estimated needs and existing funding supply result in a funding gap in the 9-County Bay Area of roughly $315 million to $570 million per year to protect against 2' of SLR (2050), and $1.5 billion to $1.76 billion per year to protect against 6.6' of SLR (2100)."

First, some salient facts:

1. The 2018 California Ocean Protection Council (OPC) State guidance on SLR forecasts 2' feet of SLR by 2050 and 6.6' feet of SLR by 2100 as a likely possibility in its Medium-High Risk aversion scenario.
2. The remaining wetlands in the Bay Area are at the risk of being lost due to SLR by 2100[1]. These critical ecosystems provide many benefits including habitats, biodiversity, stormwater retention, wave attenuation, carbon sequestration and recreation.
6. The estimated needs and existing funding supply result in a funding gap in the 9-County Bay Area of roughly $315 million to $570 million per year to protect against 2' of SLR (2050), and $1.5 billion to $1.76 billion per year to protect against 6.6' of SLR (2100). This funding gap estimate will change, and may change dramatically, as the region undertakes more detailed risk analysis. These are only estimates based on existing information collected from a wide variety of sources.

1 Goals Project. 2015. The Baylands and Climate Change: What We Can Do. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.
2 Wood, N., Jones, J.M., Henry K., Ng, P., Hou, C.Y., 2020, Hazard Exposure Reporting and Analytics – Coastal Flooding Tool, U.S. Geological Survey web application, https://www.usgs.gov/apps/hera/floodTool.php

Table 1 gives an overview of the region's estimated total annual need, total annual existing revenues, and the resulting total funding gap, as well as a breakdown of this gap by gross regional product, per capita, per household, and per parcel. These figures are based on a literature review and BCDC's internal calculations.

It is critical to consider the analysis in this paper alongside the many unknowns and uncertainties inherent in estimating funding needs for SLR. These include the expected rate and timing of various SLR scenarios, proposed flood protection heights, infrastructure costs including stormwater management, impacts from groundwater rise, disproportionate economic impacts to vulnerable communities, population and economic growth, insurance rate and coverage changes, and the implications of existing and future policies, permits and regulations on adaptation projects and novel financing tools. Clearly, not all of these factors are within the control of decision-makers and voters and their variability may well lead to either major breakthroughs or major hurdles for addressing the funding needs for SLR adaptation – or both!

Compounding this uncertainty is that both the distribution of SLR risks and the possible supplies of public funding around the region are highly variable. The uneven distribution of risk, costs from damages, funding needs, and funding supplies could result in unequal adaptation responses around the region. One of the lessons of this paper is the need for regional agreements, coordination, collaboration, and partnerships to ensure that funding is distributed equitably.

A regional funding strategy, as identified in the Bay Adapt Joint Platform[1] and informed by the data in this study and by MTC/ABAG's funding analysis as part of Plan Bay Area 2050[2], can support more equitable distribution of adaptation funding to support our diverse region, identify new potential regional funding mechanisms, and help pave the way for a fair share of state and federal funding. The need for this funding discussion is urgent; this year's State budget includes billions of dollars in funding to address critical climate change and climate adaption needs in California. Given that two-thirds of all negative SLR impacts in California will occur in the San Francisco Bay Area[3], BCDC will work with our local and regional partners to advocate for an equitable share of such funding to protect the Bay Area's coastal communities and habitats.

1 Bay Adapt Joint Platform: https://www.bayadapt.org/jointplatform/
2 MTC/ABAG, "Plan Bay Area 2050", https://www.planbayarea.org/sites/default/files/documents/Plan_Bay_Area_2050_October_2021.pdf
3 Barnard et al., "Dynamic Flood Modeling Essential to Assess the Coastal Impacts of Climate Change."

Table 1. Estimated Annual Revenue Needs for SLR Adaptation Spending in the Bay Area. See Sections "Funding Supply" and "Funding Gap" for a description of the methodology behind these values.

Category	Definition	2 Feet of SLR by 2050 (30-year Funding Period)	6.6 Feet of SLR by 2100 (80-year Funding Period)
Potential **Total Annual Need** for the Region	Estimates of Total Annual Adaptation Costs for the Region	$633 million	$1,825 million
Potential **Total Existing Annual Funding** for the Region	1%-5%* of Total City and Special District Expenditures & State and Federal Revenue	$63.7 million - $318.5 million	$63.7 million - $318.5 million
Potential **Total Annual Funding Gap** for the Region	Additional Annual Funding Needed for the Region	**$315 million – $570 million**	**$1,507 million –$1,761 million**

The Total Annual Funding Gap can be expressed as:

% Bay Area GDP Annual Funding Gap	0.05% – 0.1%	0.25% – 0.3%
Per Capita Annual Funding Gap	$41 - $74	$196 - $229
Per Household Annual Funding Gap	$117 - $211	$558 - $652
Per Parcel Annual Funding Gap	$166 – $300	$793 – $927

Potential

**Theoretical range of current expenditure and revenues that could be made available for adaptation projects based on cities' capital outlay and debt service expenditures between 2017 and 2019.*

Introduction

Paper Overview

This paper gives an introduction and overview of the current state of funding for sea level rise adaptation in the Bay Area. By demystifying the costs of adapting to SLR in the Bay Area, this paper can help initiate the way towards a regional adaptation funding strategy and assist regional planning processes, such as Bay Adapt and Plan Bay Area, and local planning for sea level rise funding. The following questions are analyzed:

1. Damages: How much economic damage is likely to occur due to flooding from SLR if no actions are taken? How does this compare to the damages likely from other natural hazards?
2. Funding Needs: How much money is likely needed for the Bay Area to reduce flood risk from SLR over the next several decades? How much do existing and planned on-the-ground case study projects in the Bay Area cost?
3. Existing Funding Sources: How much money has been available per year for local governments in the Bay Area from local, regional, state and federal sources and in what forms?
4. Funding Gap: What is the preliminary estimated funding gap to adapt the region to SLR (or what is the difference between the adaptation need and potential revenues)?

The outline of this paper is shown in Figure 1. The first two sections provide information on the costs of potential damages from sea level rise ***without*** adaptation and then compares that to how much adaptation may cost throughout the region. The following sections look at the history and current state of public spending, a percentage of which needs to be additionally raised or reallocated for natural disaster and climate change adaptation.

This section also provides a speculative outlook on, and recommendations for, the future of funding and financing adaptation.

It is important to keep in mind throughout this paper that all cost estimates are high-level, rough order-of-magnitude estimates—there are still many unknowns about impacts, costs, and funding sources that would help to contribute to a more accurate picture over time.

Background and Context: Adaptation in the Bay Area

Many Bay Area cities and counties have taken a proactive approach to climate change, including sea level rise adaptation. A large percentage have or are in the process of developing vulnerability assessments, adaptation plans, and adaptation projects to manage the risks from the sea level rise crisis. Of these, some have begun moving from adaptation planning to project funding, as there are several examples of cities using local bonds or taxes to raise funds for adaptation projects. These local initiatives will play the largest role in ensuring the region's risk-reduction from the consequences of sea level rise, as most land use and infrastructure projects are planned, managed, implemented, and maintained by local jurisdictions.

It is unlikely, however, that local initiatives alone will be sufficient to address this regional challenge. Because of this, many region-wide initiatives are working toward implementable solutions to SLR; these include the Metropolitan Transportation Commission/ Association of Bay Area Governments' (MTC/ABAG) Plan Bay Area 2050[1], the Bay Area Climate Adaptation Network (BayCAN), San Francisco Estuary Partnership's (SFEP) Estuary Blueprint[2], the San Francisco Bay Restoration Authority's (SFBRA) Measure AA, the San Francisco Estuary Institute's (SFEI) Adaptation Atlas[3]

1 MTC/ABAG, "Plan Bay Area 2050", https://www.planbayarea.org/sites/default/files/documents/Plan_Bay_Area_2050_October_2021.pdf

2 2016 Comprehensive Conservation and Management Plan for the San Francisco Estuary (Estuary Blueprint), San Francisco Estuary Partnership

3 Beagle, J.; Lowe, J.; McKnight, K.; Safran, S. M.; Tam, L.; Szambelan, S. Jo. 2019. San Francisco Bay Shoreline Adaptation Atlas:

Key Components of the Paper

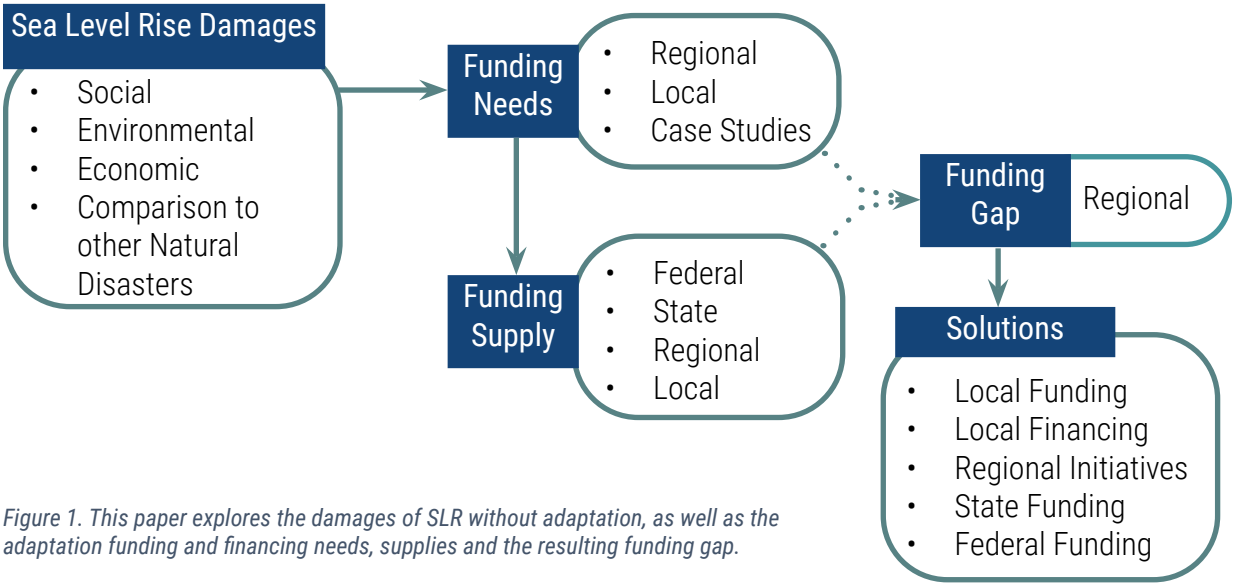

Figure 1. This paper explores the damages of SLR without adaptation, as well as the adaptation funding and financing needs, supplies and the resulting funding gap.

and San Francisco Bay Conservation and Development Commission's (BCDC) ART Bay Area[1] project as well as the BCDC-facilitated Bay Adapt[2] initiative, among many others.

Plan Bay Area 2050 is the Bay Area's long-range transportation and land use plan through the year 2050, which is was adopted in Fall 2021. It outlines a future roadmap for the Bay Area, the policies and investments necessary to advance a more affordable, connected, diverse, healthy, and vibrant Bay Area. Of the thirty-five regional strategies suggested in Plan Bay Area, one is focused entirely on sea level rise adaptation. In Plan Bay Area 2050, analysts developed "straw-man" adaptation costs that respond to their analysis of the impacts of sea level rise on future growth, resulting in a financial Needs and Revenue assessment for the region that highlights the regional funding gap. Plan Bay Area 2050's Implementation Plan outlines how to implement the Plan's strategies in the next 1-5 years, including adapting to sea level rise.

Bay Adapt is a regional initiative facilitated by BCDC that aims to build consensus around the region on sea level rise strategies. While implementation is underway at the time of publication of this report, the initiative has developed a series of regional adaptation actions that include topics like establishing regional "best practice" standards, elevating the voice of communities and community-based organizations in adaptation conversations, creating a public education campaign, streamlining regional and local planning, permitting, and policies, a regional funding strategy, legislative approach, and providing technical assistance to local cities and counties. The actions underwent public comment and will hopefully lead to the commitment of Bay Area leaders to implement these actions in 2022 and beyond.

Ultimately, funding is frequently identified as a big challenge to overcome when implementing any possible solutions. A large challenge the Bay Area will face is how municipalities and the region will pay for adaptation projects to protect communities and

Working with Nature to Plan for Sea Level Rise Using Operational Landscape Units. SFEI Contribution No. 915. SFEI & SPUR: Richmond, CA. p 255.

1 Adapting to Rising Tides 2020. Adapting to Rising Tides Bay Area: Regional Sea Level Rise Vulnerability and Adaptation Study. Bay Conservation and Development Commission (BCDC) and Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG), San Francisco CA.

2 Bay Adapt Joint Platform: https://www.bayadapt.org/jointplatform/

habitats from sea level rise. The issue of sea level rise in the Bay Area will affect the entire Californian economy as the Bay Area is anticipated to receive two-thirds of all socioeconomic impacts caused from projected flooding in all of California.[1]

Equity and Environmental Justice Considerations

Without improving the understanding of the regional funding gap for adaptation that the Bay Area faces and implementing a just distribution of funds, there is no clear pathway forward to creating an equitable and resilient Bay Area. This is because the effects of climate change and sea level rise will not be felt by all people equally. Even in cases where flooding is comparable, existing social and economic conditions, as well as existing contamination burdens, will influence how severe the disruption will be across households.

Low-income communities are more likely to be located near contaminated, low-lying areas that are vulnerable to sea level rise.[2] These communities are also likely to be facing other threats like gentrification and social displacement. In almost all locations where social vulnerability is present, gentrification and displacement are either ongoing or pose potential threats to community cohesion.[3] Gentrification and flooding are dual drivers of displacement that pose risks to socially vulnerable populations. In addition, many vulnerable shoreline communities are located adjacent to hazardous waste sites. Contaminants at these sites may become mobilized by flooding, compounding threats to the community. An unequal distribution of adaptation solutions could deepen inequity and increase vulnerabilities for low-income communities. An additional concern regarding SLR adaptation is an increased financial burden on low-income communities created by potentially regressive adaptation funding mechanisms, including local match requirements. While this paper does not focus on individual funding or financing mechanisms for projects, it is important to consider who is paying, who benefits, and how things are paid for. Understanding these nuances of inequity in funding and financing tools is essential to building equitable adaptation in the Bay. A regional funding strategy could spell out specific guidelines for more equitable financing and funding measures, as well as redistribute revenues around the region so that it goes where it is most needed, not where there are the most resources.

Constant Dollar Values

In order to make comparisons of all these large dollar values across many years easier, most values were converted to 2020 U.S. dollar values using the U.S. Bureau of Labor Statistic's Consumer Price Index (CPI) (All Goods). The CPI "is a measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services. Indexes are available for the U.S. and various geographic areas".[4] In some reports the year of a dollar value was not stated and was assumed to be the value during the year of the described event.

Funding Versus Financing Definitions

For the purposes of this paper, we use the following definitions:

- **Funding:** direct revenue or cash to pay for projects; e.g. through taxes, fees and grants.
- **Financing:** project payment over time by borrowing money from institutions; provision of the initial cash for the projects at a return rate; e.g. a loan or a bond.

1 Barnard et al., "Dynamic Flood Modeling Essential to Assess the Coastal Impacts of Climate Change."
2 Bay Conservation and Development Commission (BCDC) and Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG), "Adapting to Rising Tides Bay Area: Regional Sea Level Rise Vulnerability and Adaptation Study."
3 Bay Conservation and Development Commission (BCDC) and Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG).
4 U.S. Bureau of Labor Statistics, "CPI Home."

This paper mainly focuses on funding (i.e. grants, taxes, fees, etc.) with the addition of currently proposed State and regional funding, rather than financing, though local financing will likely play a significant role in closing the funding gap for cities, counties, and the region.

Defining Adaptation

In this paper, adaptation refers only to adaptation to flooding from sea level rise. Furthermore, only the costs of structural adaptation actions, including both gray and green infrastructure, are considered here. Structural adaptation actions (referred to as "adaptation") refer to physical shoreline projects that change the shoreline to prevent overtopping of water due to flooding and sea level rise from reaching infrastructure, such as homes or roads. Adaptation projects can include levees, wetland conservation, raising roads, building "living shorelines" and stormwater management.

This paper's analysis does not explicitly consider the cost of non-structural adaptation projects such as land acquisition or infrastructure and building relocation, elevation, and flood-proofing. Further, it does not include the cost of planning and permitting of adaptation, such as General Plan updates, citywide vulnerability assessments, Local Hazard Mitigation Plan updates, Adaptation Plans, California Environmental Quality Act (CEQA) and other permitting requirements or policy-based adaptation solutions such as zoning changes, or the essential community engagement that should be a part of these planning processes. As noted above, funding for this planning and analysis is critical. Additionally, this paper does not discuss future insurance rate or coverage changes due to SLR and adaptation.

Unknowns

Uncertainties or information gaps in estimating costs throughout this paper are identified in the 'Unknowns' sections of each chapter. The sea level rise damages and the associated adaptation costs identified in this paper are high-level estimates which could significantly change as uncertainties, unknowns, and information gaps are addressed. The following are a summary of the uncertainties listed in this paper:

- **Damages**
    - Impacts of sea level rise on groundwater levels and salinity, in combination with riverine flooding (current flood models include neither), leading to potentially more damages.
    - The disproportional cost burden for disadvantaged communities that accounts for their flood risk and available public and private funding to pay for adaptation.
    - Total impacts of SLR in economic and non-economic terms, such as lost habitat, ecosystem functions, or human displacement.
- **Costs & Benefits**
    - Specific local plans for SLR protection strategies.
    - Changes to flood insurance rates or coverage based on SLR and employed adaptation strategies.
    - The cost and availability of fill (or sediment) and other materials needed for projects such as levees, wetland restoration, or elevating land.
- **Revenues**
    - New, or reforms to existing California tax policies (i.e., Prop. 218 and 13) and how they may impact potential local funding revenues.
    - Population growth.
    - Economic growth.
    - Future state & federal budget policies.

Damages: Sea Level Rise Damages Without Adaptation

There are significant uncertainties regarding climate change and our adaptation to it; for example, greenhouse gas emissions scenarios which impact pace and timing of sea level rise, and which adaptation strategies will be employed where. What is certain is that over the next several decades sea level rise will drastically change the shape of the Bay and cause greater financial stress for jurisdictions in the absence of adequate planning.

that are more challenging to monetize, and these fiscal impacts will be felt by a range of entities, from private individuals to large corporations and governments.

This paper focuses on direct property damages via parcel value because they are easily measured and monetized, though it is important to emphasize that only using the measure of parcel value as a proxy for sea level rise consequences is flawed—wealthier

"What is certain is that over the next several decades sea level rise will drastically change the shape of the Bay and cause greater financial stress for jurisdictions in the absence of adequate planning."

There are many types of damages that will be caused by SLR, including destruction of private and public property and infrastructure, loss of habitat and ecosystem services, and social impacts to people such as displacement from their homes and increased contamination burdens. Each will have different fiscal impacts, from direct loss of property to indirect losses

communities will always seem more impacted than poorer communities since they have higher property values. A more thorough flood risk analysis should examine all economic impacts, including damage to infrastructure, indirect and induced damages and non-economic damage to habitat.
Many other sea level rise impacts will cause economic

Figure 2. Different types of damages caused by sea level rise. Property damages are quantified in this study, while the other damages are difficult to monetize.

stress but are more difficult to monetize, for example, water quality impacts from contaminated lands being mobilized during flooding, habitat change and loss, the impacts of a community being displaced, or transportation routes being severed due to flooding. ART Bay Area, a regional vulnerability and adaptation study released by BCDC and MTC/ABAG in 2020, measures sea level rise impacts through a series of 32 consequence indicators to understand where the biggest impacts are in the Bay Area despite the distribution of wealth. Please refer to ART Bay Area for more information.[1]

Property Damages for the Bay Area

In this section property damages are based on parcel value, including both improved and land value, as represented by tax assessments and analyzed at various sea level rise scenarios. Utilizing tax-based parcel value likely significantly underestimates actual damage costs as many older properties are assessed far below their market value due to Proposition 13. However, it allows us to establish a preliminary, albeit likely low, understanding of the magnitude of financial impacts to private property. Residential properties represent 51% of all assets at risk based on building replacement value. Commercial and industrial sectors also constitute a similarly high percentage of assets at risk at 46% each, while agriculture, education, religion, and government make up only about 3% of the assets at risk when combined.[2]

Table 2 summarizes the potential property damages caused by various sea level rise scenarios for the Bay Area. This data is provided by the United State Geological Service's (USGS) Hazard Exposure Reporting and Analytics (HERA) project[3], which "was developed to provide users with insight on potential population, economic, land cover, and infrastructure vulnerability resulting from a given hazard".

According to HERA, the value of parcels in SLR flood hazard zones in the Bay Area ranges from $47.1 billion (2020 $) for 3.3 feet of SLR to $102 billion (2020 $) for 6.6 feet of SLR (with large uncertainty ranges). A 100-year storm is also assessed on top of every sea level rise scenario, which is a storm that has a 1% chance of happening in every year and is a standard flood risk used by the Federal Emergency Management Agency (FEMA). When adding a 100-year storm, these property damages increase to $73.7 billion for 3.3 feet of SLR and $147.6 billion for 6.6 feet of SLR (2020 $),[4] or almost a 50% increase in the property value at risk. This increase is significant, but the 100-year storm has an even greater impact at lower SLR heights, increasing property damages by a factor ranging from two to ten.

1 Adapting to Rising Tides 2020. Adapting to Rising Tides Bay Area: Regional Sea Level Rise Vulnerability and Adaptation Study. Bay Conservation and Development Commission (BCDC) and Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG), San Francisco CA.

2 Heberger et al., "The Impacts of Sea Level Rise on the San Francisco Bay."

3 Wood, N., Jones, J.M., Henry K., Ng, P., Hou, C.Y., 2020, Hazard Exposure Reporting and Analytics – Coastal Flooding Tool, U.S. Geological Survey web application, https://www.usgs.gov/apps/hera/floodTool.php

4 Barnard et al., "Dynamic Flood Modeling Essential to Assess the Coastal Impacts of Climate Change."

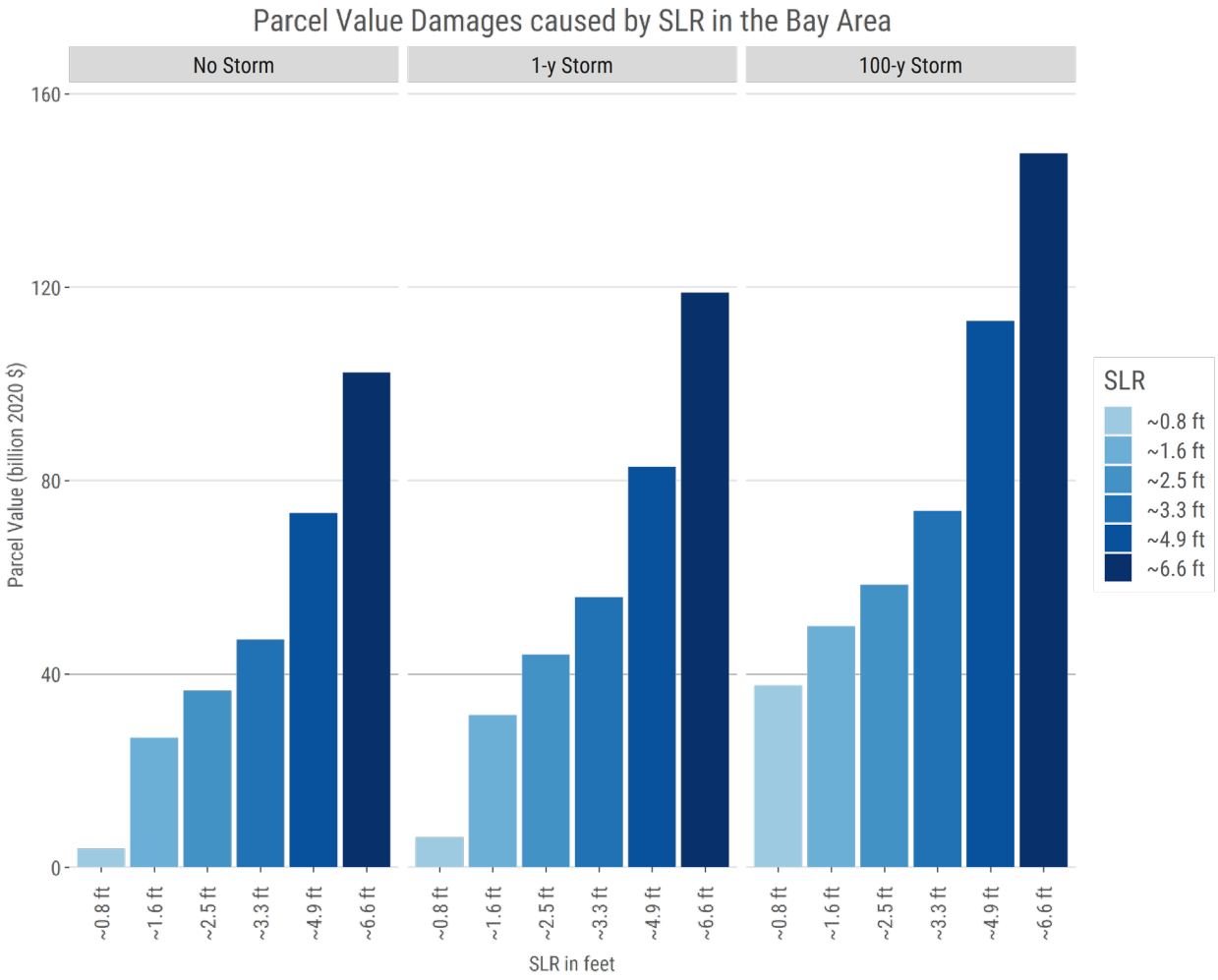

Figure 3. Total impacted USGS HERA parcel value estimates, including both improved and land values, by SLR and storm scenarios in 2020 USD for the nine-County Bay Area. SLR inches converted from metric system and rounded.

Table 2. Summary table of various sea level rise impacts to property damages for the Bay Area as reported by USGS HERA as measured in parcel value.

	Bay Area Property Damages (As Measured as Parcel Value) With No Additional Adaptation Done To The Shoreline (2020 dollars)	
Sea Level Rise Scenario	**With No Storm**	**With a 100-year Storm**
0.8 feet	$3.8 billion	$37.7 billion
1.6 feet	$26.9 billion	$49.9 billion
2.5 feet	$36.6 billion	$58.4 billion
3.3 feet	$47.1 billion	$73.7 billion
4.9 feet	$73.2 billion	$113 billion
6.6 feet	$102 billion	$148 billion

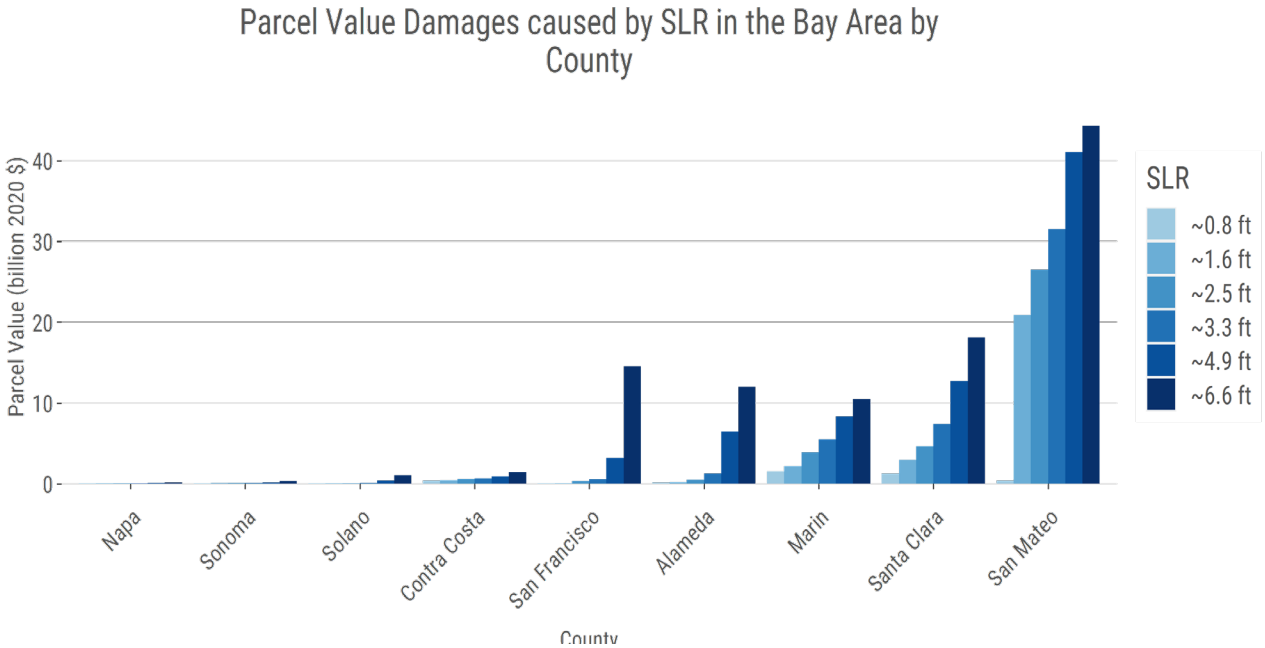

Figure 4. Total impacted USGS HERA parcel value estimates, including both improved and land value, by SLR summarized by county in 2020 USD for the nine-County Bay Area. SLR inches converted from metric system and rounded.

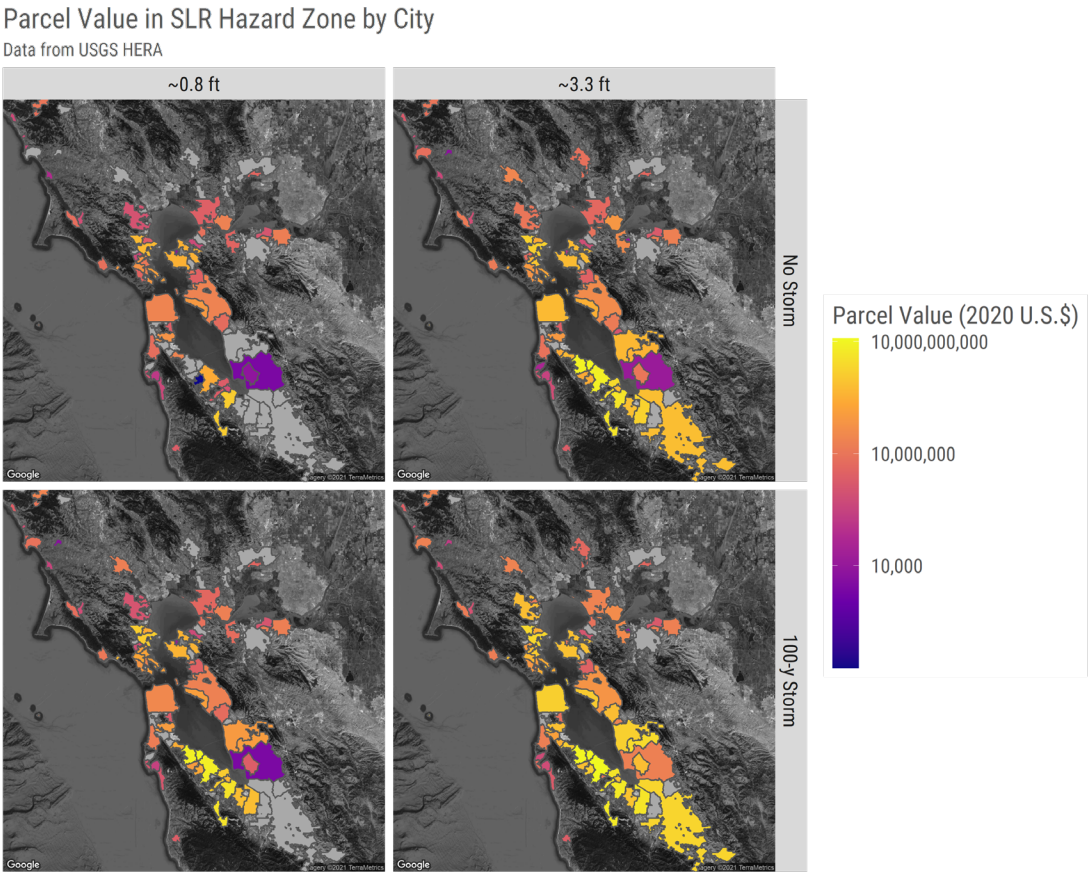

Figure 5. This map shows the parcel values (in 2020 dollars) aggregated by City that may be affected by 0.8 feet or 3.3 feet of sea level rise alone, and then sea level rise in combination with a 100-year storm (a 1% chance happening in each year). Cities in the North and East Bay experience lower parcel value damages from sea level rise compared to cities in Marin, Santa Clara, and San Mateo. Grey colored cities have no measured parcels inundated at that level.

Property Damages by County and City

Comparing sea level rise impacts around the Bay Area by county, San Mateo County could experience the highest overall property damages from sea level rise alone (see Figure 4). Alameda and San Francisco Counties both face relatively low property damages at lower flood levels but experience dramatic increases in damages as sea levels rise. The earliest impacts are expected in Marin and Santa Clara Counties with steady increases as sea levels rise. Contra Costa County in the East Bay and Solano, Sonoma and Napa Counties in the North Bay all have relatively low property damages from sea level rise compared to the rest of the Bay Area.

Comparing sea level rise impacts around the Bay Area by city (see the maps in Figure 5), the earliest impacts at 0.8 ft of SLR are spread throughout the Bay Area, with greatest damages seen in Palo Alto, San Rafael, Richmond, and Redwood City. At 3.3 feet of SLR, the highest value property damages are concentrated in cities in San Mateo County such as Foster City*, San Mateo and Redwood City.

Sea Level Rise Damage Unknowns

Here we list several categories of SLR damages and impacts not covered in this paper. Many of these need further economic analysis and could draw on existing funding sources specifically targeted at researching these topics.

Infrastructure Damages From SLR

The monetary damages from SLR cited above only include property value damages and do not include monetary damages to public infrastructure such as wastewater treatment plants, water treatment plants, roads, subways, railroads, wells, septic systems, landfills, and other such items. Damages from direct and indirect impacts to infrastructure, such as electrical system damages from contact with water, structural damages, or an interruption or shutdown of systems are likely to be very high. Wastewater and stormwater conveyance systems serving communities around the Bay were constructed assuming static Bay water levels. Federal funding for infrastructure may be an additional revenue stream for researching these impacts.

Groundwater Damages From SLR

The economic models above are focused on shoreline flooding and do not include groundwater impacts in addition to sea level rise flooding. Groundwater will begin to rise as sea level rises, adding more extensive flooding than originally thought and potentially impacting existing flood protection.

Rising groundwater from the tidally influenced Bay can potentially corrode underground pipes, create increased roadway failure, leach contaminants from landfills, cause reduced sewer and septic drainage, and cause other damages to underground utilities and structures. It also has the potential for mobilizing contaminants in soils currently above the water table as the water table rises with higher sea levels, leading to the need for expensive cleanup efforts. These additional damages from groundwater impacts are not included in our property damage costs listed above and will likely add significant damage costs.

A recent USGS study found that with 3.3 ft of sea level rise, areas flooded from below via groundwater are predicted to expand about 160 to 430 feet inland which could correspond to around a 20% increase in the total flooded area, and that low-lying coastal communities such as those around San Francisco Bay are most at risk.[1] At the time of this paper USGS, SFEI and UC Berkeley are also conducting studies to explore how groundwater will impact our existing sea level rise estimates in the Bay Area.

1 Befus et al., "Increasing Threat of Coastal Groundwater Hazards from Sea-Level Rise in California."
* At the time of writing, the Foster City Levee Improvements Project is currently under construction

Social and Environmental Costs from SLR

Social and environmental costs, or non-market costs, from sea level rise are important to consider when looking at monetary costs throughout this paper, as many of these damages have been ignored in traditional cost-benefit analyses (CBA) of adaptation project proposals. However, many funding programs, such as from FEMA or US Army Corps of Engineers, have recently been changing their CBA formulas to include harder to quantify social and environmental costs and benefits in determining whether a project is eligible for funding.

The ART Bay Area report completed an analysis of non-monetary flooding impacts.[1] Some high-level findings show that with three feet of flooding, anticipated to occur over the next 40 to 100 years, we could see regionwide flooding impacts to various systems. The following list includes some of the major takeaways:

- At 36" TWL, impacts to critical regional habitats and ecosystem services reach near-peak levels.
- The Bay Bridge touchdown starts to flood, severely impacting cross-bay movement. Over 33 million annual passenger boardings and 1.6 billion pounds of cargo at airports are at risk.
- Significant jumps in impacts continue in Priority Development Areas, with 154,640 planned jobs and 64,400 planned housing units at risk around the region.
- Impacts in socially-vulnerable communities reaches nearly 15,000 households, with over 2/3 of these also exposed to contaminated sites.

Figure 6- Map showing the Bay Area block groups (blue areas) with high contamination vulnerability and exposure to 3 feet of SLR. Source: ART Bay Area.

The consequences listed above are not included in the property damages from sea level rise estimated in this chapter, which is important to consider when looking at total damages to the Bay Area, as 'true' costs will be much higher than just property damages. There is a need for more thorough analysis of the economic consequences of social and environmental damages caused by flooding in the Bay Area.

1 Adapting to Rising Tides 2020. Adapting to Rising Tides Bay Area: Regional Sea Level Rise Vulnerability and Adaptation Study. Bay Conservation and Development Commission (BCDC) and Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG), San Francisco CA.

Socioeconomic Costs

The economic models based on property damages above do not include full monetary damages to communities themselves, such as the impacts to jobs, housing prices, commerce, commuting, recreation, health and wellbeing, displacement, and vulnerable residents.

The effects of climate change and sea level rise will not be felt by all people equally. Even in cases where flooding is comparable, existing social and economic conditions, such as community resilience, social capacity, and individual and community resources, as well as existing contamination burdens, will influence how severe the disruption will be across households.

Many disadvantaged communities are in low-lying areas surrounded by contaminated lands, such as Pittsburg and Oakland in the East Bay, San Rafael in the North Bay, or Alviso in the South Bay (see Figure 6). These contaminants could become mobilized during flooding, potentially polluting nearby lands. This will create huge unknown costs for remediation and cleanup in communities, as well as health impacts. This has environmental justice concerns, putting the burden on low-income communities of color.

Further, the flooding pressure on low-lying areas will increase displacement, which will hit the already disadvantaged communities hardest, since these communities generally have lower rates of flood insurance and savings to relocate easily.

Environmental Costs

ART Bay Area and the Natural Capital Project determined there are 35,150 acres of tidal marsh submerged at three feet of sea level rise, which is within the range of 2060-2070 projections. This translates into an economic loss of between $88.7 million to $11.14 billion one-time in environmental and recreational benefits based off estimates used by the EPA.[1] Ecosystems also give value in stormwater retention, carbon sequestration, and biodiversity.

As mentioned above, many environmental damages run the danger of being ignored in cost-benefit analyses of adaptation project proposals. This white paper does not include extensive research on ecosystem valuations for the Bay Area. However, ecosystem valuations, which assigns a value to the ecosystem or the service it provides (such as water filtration or wave attenuation), have evolved to provide a more sophisticated and acceptable way to summarize the benefits the environment brings to an area. For resources on the impacts of losing ecosystem functions, recreation, carbon storage, and endangered species, please see ART Bay Area's work with the Natural Capital Project for more information.

Comparison of Economic Damages of SLR to Other U.S. Natural Disasters

Sea level rise is only one of several natural hazards posing threats to societies, ecosystems and economies in the Bay Area and around the globe. The economic damages caused by some of these recent events have been quantified and can allow us to compare these historic costs to the projected costs of sea level rise in the Bay Area. This can help understand the context and magnitude of these costs and the funds we will need to mobilize to prevent some of these damages. SLR is comparable the most extreme and expensive natural disasters in terms of economic costs. All past events have been adjusted to 2020 dollars to allow for more meaningful comparison.

The U.S. has sustained 273 weather and climate disasters between 1980 and 2020 where overall damages reached or exceeded $1 billion (2020 U.S. dollars). The total cost of these 273 events exceeds $1.8 trillion.[2] On average this equates to $45 billion annually across the United States and will only increase with climate change. Just in the last five years there has been $535 billion in damages, or $107 billion per year, twice the average damages experienced over the last 40 years.

1 Raheem et al., "The Economic Value of Coastal Ecosystems in California."
2 Smith and NOAA National Centers For Environmental Information, "U.S. Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)."

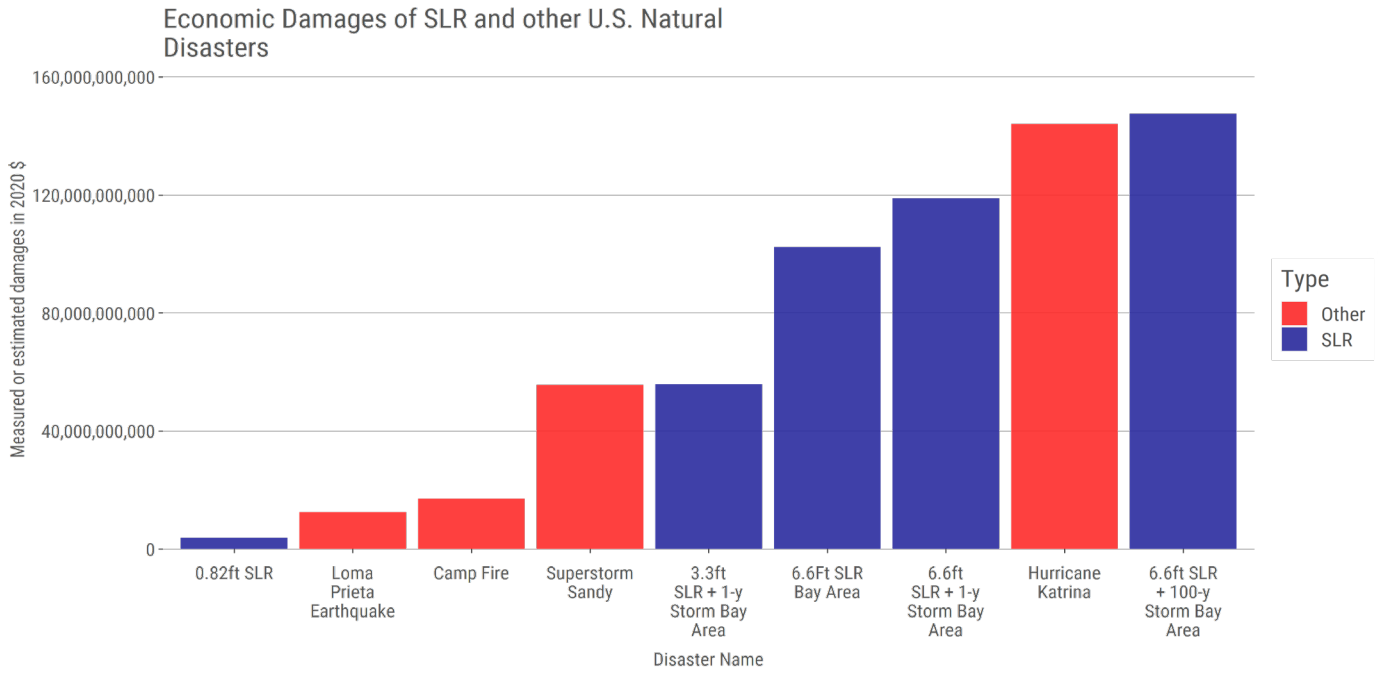

Figure 7. The economic damages of past and projected U.S. natural disasters adjusted to 2020 U.S. dollars.

The Bay Area's Loma Prieta Earthquake (1989) caused $12.5 billion in damage (2020 U.S. dollars)[1,2], Hurricane Katrina in the New Orleans metro area (1995) caused $144 billion in damage (2020 U.S. dollars)[3], Superstorm Sandy in the New York metro area (2012) caused $55.6 billion in damage (2020 U.S. dollars)[4], and Northern California's recent Camp Fire (2018) caused $17 billion in damage (in 2020 U.S. dollars).[5] Sea level rise property damages in the Bay Area are on par some of the nation's worst fires and storms. In comparison, 3.3 feet of SLR with a 1-year storm could cause $55.8 billion of losses in parcel values in the Bay Area, almost three times the damages caused by the Camp Fire and close to the damages caused by Superstorm Sandy. At 6.6 feet of SLR with a 1-year storm, the Bay Area could see upwards of $118.8 billion worth of parcel value losses which makes it comparable with Hurricane Katrina, the costliest natural disaster in US history as of 2020.[6] A comparison of these damages can be seen in Figure 7.

Typically, disaster events like wildfires, earthquakes, and storms occur suddenly and temporarily (i.e. structures can be rebuilt after the disaster event). Sea level rise and its associated damages on the other hand is a slow-moving and permanent disaster. The fact that damages will worsen over time rather than all at once could allow for more time to prevent or reduce these damages, limiting their economic impact. However, unlike other disaster events, damages due to SLR will also hit the entire U.S. coast and the world simultaneously, creating more competition for adaptation dollars. These factors point to advantages to paying for adaptation now versus waiting to adapt later when damages have begun to aggregate and there is a high competition for disaster funds.

1 Note: population size and GDP in the Bay Area has increased drastically since 1989, which would result in higher damages if it happened today
2 Board and Council, Practical Lessons from the Loma Prieta Earthquake.
3 Knabb, Rhome, and Brown, Tropical Cyclone Report Hurricane Katrina (AL122005) 23-30 August 2005. National Hurricane Center.
4 Blake et al., Tropical Cyclone Report: Hurricane Sandy (AL182012) 22 – 29 October 2012. National Hurricane ***Center***.
5 Faust and Steuer, "New Hazard and Risk Level for Wildfires in California and Worldwide."
6 statista, "Most Expensive Natural Disasters in the United States as of April 2020."

Funding Needs: Cost Estimates for Adaptation in the Bay

This section uncovers the potential costs of building physical adaptation projects in the Bay Area but excludes costs and trade-offs of planning, land use policy (i.e., managed retreat) or other regulatory changes. As cited in the previous section, there are huge economic consequences of sea level rise adaptation inaction. Shoreline protection projects, despite their high upfront costs, could reduce total costs over time as they may reduce the magnitude of flood damages from sea level rise and storms. However, planning and building adaptation projects will also cost the region and municipalities funds that they do not currently have a budget for.

Costs vs Benefits

A study by the National Institute of Building Sciences, called "Natural Hazard Mitigation Saves: 2019 Interim Report", determined that there is a savings of $6 in recovery costs for every $1 spent on hazard mitigation efforts through federal grants, and savings of $4 in recovery costs for every $1 spent surpassing standard building codes for floodproofing when using a 2.2% cost-of-borrowing discount rate. This makes a strong argument for building adaptation into the region at an early phase to reduce total spending over time. However, there are multiple reasons why a traditional cost-benefit analysis may not support the cost of adaptation projects, as outlined in ***Damages***. These should be carefully weighed when identifying costs and benefits.

Discount Rates

The typical infrastructure discount rate used in discounted cash flow analysis, which aims to capture the time value of money as well as the uncertainty of cash flow, lowers the value of investments into the future. A dollar today is worth more than a dollar in the future because one can invest it with interest, meaning the sooner money is received, the more interest it can accrue and the more it will be worth in the future. In the U.S., the White House Office of Management and Budget (OBM) has commonly used a 7% discount rate for infrastructure projects. When using a 7% discount rate, projects that have long lifespans over several decades have a harder time reaching a positive Benefit-Cost-Ratio, which is required to be approved and funded. This is particularly a barrier for large, long-term climate adaptation projects. In the years since 2009, the discount rate has been steadily falling and is now at a historical low, making large infrastructure projects more attractive. For 2021, the OBM has set the 30-year nominal discount rate at 1.7%. The used rate will affect the affordability of adaptation projects.[1]

Gray Versus Green Adaptation

Across the region, shoreline adaptation projects could include gray, green, and hybrid infrastructure strategies to protect against flooding and sea level rise. Gray infrastructure refers to hardened, engineered approaches such as sea walls, levees, and rip rap (large rocks). Green infrastructure along the shoreline, also known as nature-based adaptation or living shorelines, refers to the use of natural systems such as salt marshes, oyster reefs, and/or beaches for improved flood protection. Hybrid approaches include projects that use elements of both green and gray, such as "horizontal levees" (also called ecotone levees) which use natural marsh habitat on the waterside of a gently sloping levee to stabilize the shoreline and prevent erosion while also creating habitat and space for marsh to migrate upwards as sea levels rise.

Traditionally, gray infrastructure has been the common approach to building flood protection. However, there is an increasing recognition that green infrastructure, when used in the right conditions, can have additional multiple benefits. For example, in addition to reducing flood risk, nature-based approaches can increase biodiversity and wildlife populations, improve water

1 White House Office of Management and Budget, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses (2021)."

quality by reducing pollution loads, sequester and store carbon, and enhance recreation opportunities and access to nature. These additional benefits that nature provides to people are called ecosystem services. Because these natural services are not traded in our economic markets, they are often overlooked in cost-benefit analyses. However, decades of research on the economic value of ecosystem services demonstrates that, when accounted for, these natural benefits can have immense economic value to society.

Gray infrastructure may have lower upfront costs, dependent on the project design, but there are also hidden costs to using traditional gray infrastructure approaches, such as long-term maintenance costs hat can be expensive compared to resilient nature-based alternatives.[1] Traditional flood protection strategies run the risk of catastrophic damage and cost in disaster scenarios such as earthquakes or extreme storms, as demonstrated by the Gulf hurricanes of the 2010s, while nature-based solutions are often designed for resiliency and mitigation of flooding impacts.[2] For example, according to the National Oceanic and Atmospheric Association (NOAA), just 15 feet of salt marsh can absorb 50 percent of wave energy, reducing flood impacts.[3]

Conversely, nature-based adaptation approaches could have higher upfront costs but provide longer-term benefits and flexibility, resulting in economic feasibility.[4] Nature-based approaches, such as established wetlands, often require much less maintenance after a storm because they can recover and adapt to changes—they are more resilient. The average cost-benefit ratio of nature-based adaptation measures is estimated to be above 3.5.[5] Wetlands and other shoreline habitats that are connected to an adequate supply of sediment and provided space to migrate upwards may be able to keep pace as sea levels rise and provide long term protection and ecosystem services benefits that are not possible with standard gray approaches. While recognizing these benefits, there are significant areas of the Bay with existing man-made shorelines, including ports and airports. Incorporating nature-based adaptations in areas with man-made shorelines adjacent to deep water poses unique challenges which must be assessed relative to the potential habitat benefits. More research is required to understand how best to promote habitat improvements in these areas, including ecological seawalls and related approaches.

Additionally, the State of California, among others, are increasingly prioritizing the use of green infrastructure due to the multiple and long-term benefits of such projects.[6,7,8,9,10] Recent state and federal legislation suggest that support for nature-based infrastructure is on the rise (such as SB-576 (2019), AB-65 (2019), and HR-3115 (2019)). For example, AB-3012 (2018) requires the Coastal Conservancy to prioritize climate change projects that maximize public benefits such as reducing emissions of greenhouse gases, preserving and enhancing coastal wetlands and natural lands, conserving biodiversity, providing recreational opportunities, reducing flood risk, and enhancing fish and wildlife habitat.

Additionally, the San Francisco Bay Area has long held regional habitat goals, such as the Baylands Ecosystem Habitat Goals[11], seeking to restore formerly destroyed

1 Smith et al., "Living Shorelines Enhanced the Resilience of Saltmarshes to Hurricane Matthew (2016)."
2 Environmental and Energy Study Institute, "Nature as Resilient Infrastructure: An Overview of Nature-Based Solutions."
3 National Oceanic and Atmospheric Administration, "What Is a Living Shoreline?"
4 Reguero et al., "Comparing the Cost Effectiveness of Nature-Based and Coastal Adaptation."
5 Reguero et al., "Comparing the Cost Effectiveness of Nature-Based and Coastal Adaptation."
6 "Natural Infrastructure."
7 Francisco, "San Francisco Bay Plan."
8 "Climate Ready Program – California State Coastal Conservancy."
9 "Safeguarding California Plan: 2018 Update."
10 "NOAA Office for Coastal Management."
11 Goals Project. 2015. The Baylands and Climate Change: What We Can Do. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.

wetlands and other coastal habitats to bring back the benefits that natural systems provide – including flood protection. Due to this, there is an increased amount of funding available to advance nature-based adaptation projects, which can help offset some of the upfront costs and potentially make a nature-based design more cost effective through access to competitive funding. In general, BCDC's Bay Plan, through the Fill for Habitat Amendment (BPA 1-17)[1], the ART program, and Bay Adapt recommend consideration of green infrastructure strategies before resorting to gray strategies to capitalize on multi-benefit projects wherever possible.

Regional Adaptation Cost Estimates

Few studies have taken on the comprehensive cost of sea level rise adaptation over the next several decades. This is because of the many variables and unknowns associated not just with which adaptation solutions will be put in place, but the wide range of cost variables for adaptation due to lack of precedent, local conditions, and myriad other factors. Below are two known studies that focus on the Bay Area, though the differences in assumptions and limitations of the studies primarily show us how much work is left to be done.

U.C. Berkeley

A 2017 study by Hirschfeld and Hill from the University of California Berkeley estimates it will take at least $40 billion (2020 USD$) to raise all existing flood control structures along the boundary between saltwater habitat and freshwater habitat (which the study calls Shoreline B) throughout the Bay Area to prevent overtopping from 0 to 3.3 feet of sea level rise. Raising existing structures to prevent overtopping between 3.3 feet and 6.6 feet of sea level rise added at least $106 billion (2020 USD$) to the cost of adapting from 0 to 3.3 feet of SLR. Raising sea walls is the most significant cost factor, responsible for 70-90% of total adaptation costs.[2] These estimates do not include costs associated with companion improvements to manage stormwater. The lowest points along the shoreline are the avenues for stormwater discharge: as we raise shorelines, new stormwater management strategies will be required.

As sea levels rise, costs rise exponentially and are approximately three to four times higher for the 6.6 feet SLR scenario as compared to the 3.3 feet scenario.[3] Additionally, building shoreline infrastructure to prevent storm flooding in addition to sea level rise doubles the costs.[4] These values also only account for ***existing*** flood control structures, not new flood control that will need to be built along portions of the shoreline that do not currently flood but will in the future.

MTC/ABAG

Plan Bay Area 2050 (2021) is the first time that MTC/ABAG assessed the regional funding need for sea level rise adaptation, assuming that the region would see 3 feet of inundation by 2050, with 2 feet of permanent inundation, and a foot of flooding due to storms and king tides. Plan Bay Area 2050 analyzed that adapting key areas of the shoreline for the impacts seen by 2050 may cost $19 billion and could protect 98% of the region's 2050 existing and future households potentially at risk of flooding from sea level rise.[5] This high-level cost analysis was developed with the help of multiple sources, including AECOM, Caltrans, national cost standards with location adjustment factors, and local Bay Area projects. This cost includes the planning, design, permitting, environmental clearance, and construction cost of shoreline protection infrastructure. It does not include environmental mitigation, land acquisition, utility relocation, and maintenance costs.[6]

1 Goldzband and Hall, "Staff Report and Preliminary Recommendation for Proposed Bay Plan Amendment No. 1-17 Concerning the Update of the Bay Plan Fill for Habitat Policies."
2 Hirschfeld and Hill, "Choosing a Future Shoreline for the San Francisco Bay."
3 Barnard et al., "Dynamic Flood Modeling Essential to Assess the Coastal Impacts of Climate Change."
4 Hirschfeld and Hill, "Choosing a Future Shoreline for the San Francisco Bay."
5 MTC/ABAG, "Plan Bay Area 2050", https://www.planbayarea.org/sites/default/files/documents/Plan_Bay_Area_2050_October_2021.pdf
6 AECOM, "A Resilient Transportation System for Safe and Sustainable Communities - Final Draft Regional Adaptation Strategies Cost Estimating Memo."

Documented Adaptation Project Costs

This section illustrates what we know about the current adaptation costs in the Bay Area. It aims to capture real costs for adaptation using projects documented through the San Francisco Bay Restoration Authority funded by Measure AA, EcoAtlas, MTC/ABAG's AECOM adaptation costing study, and other Bay Area case studies.

San Francisco Bay Restoration Authority and EcoAtlas

EcoAtlas, a Bay Area project tracking tool, covers wetland restoration, mitigation, habitat conservation, and shoreline adaptation projects. EcoAtlas has tracked about $1 billion of built or in-progress projects in the Bay Area over the last 40 years (see Figure 8), a mere fraction of the adaptation cost estimate needed for shoreline protection across the region ($19 billion for 2 ft of SLR). Around $20 million of this funding comes from the relatively recent San Francisco Bay Restoration Authority's Grant Program, funded by a $12 annual parcel tax for 20 years to fund Bay Area habitat restoration projects. The Restoration Authority and the regional measure that funded it, Measure AA, is discussed in more depth in the "Funding Adaptation Projects" chapter.

Adaptation costs per linear foot of shoreline

Bay Area specific costs per linear foot for shoreline adaptation measures were estimated by MTC/ABAG and AECOM for use in the Plan Bay Area 2050 Draft Blueprint, which were utilized for their regional cost estimate. These costs assume a design of 9 feet of elevation (7 feet of sea level rise plus 2 feet of freeboard, or extra headroom). These costs do not include environmental mitigation, land acquisition, utility relocation and maintenance costs, but they do include planning, design, and construction. It is important to note that these costs per linear foot are for magnitude of scale only and should not be used to cost specific projects around the Bay.

MTC/ABAG and AECOM's cost estimates are seen in Table 4.

Table 3. Summary table of potential sea level rise adaptation costs for the Bay Area.

Sea Level Rise Scenario	**Adaptation Costs (2020 dollars) of Adaptation in the Bay Area**	**Source**
2 feet	$19 billion	Plan Bay Area 2050 Draft Blueprint, MTC/ABAG
3.3 feet	$40 billion[a]	Hirschfeld and Hill, "Choosing a Future Shoreline for the San Francisco Bay."
6.6 feet	$146 billion[a]	Hirschfeld and Hill

[a] *Low-end of the estimate range. Only includes costs of adapting existing flood control structures, not new projects.*

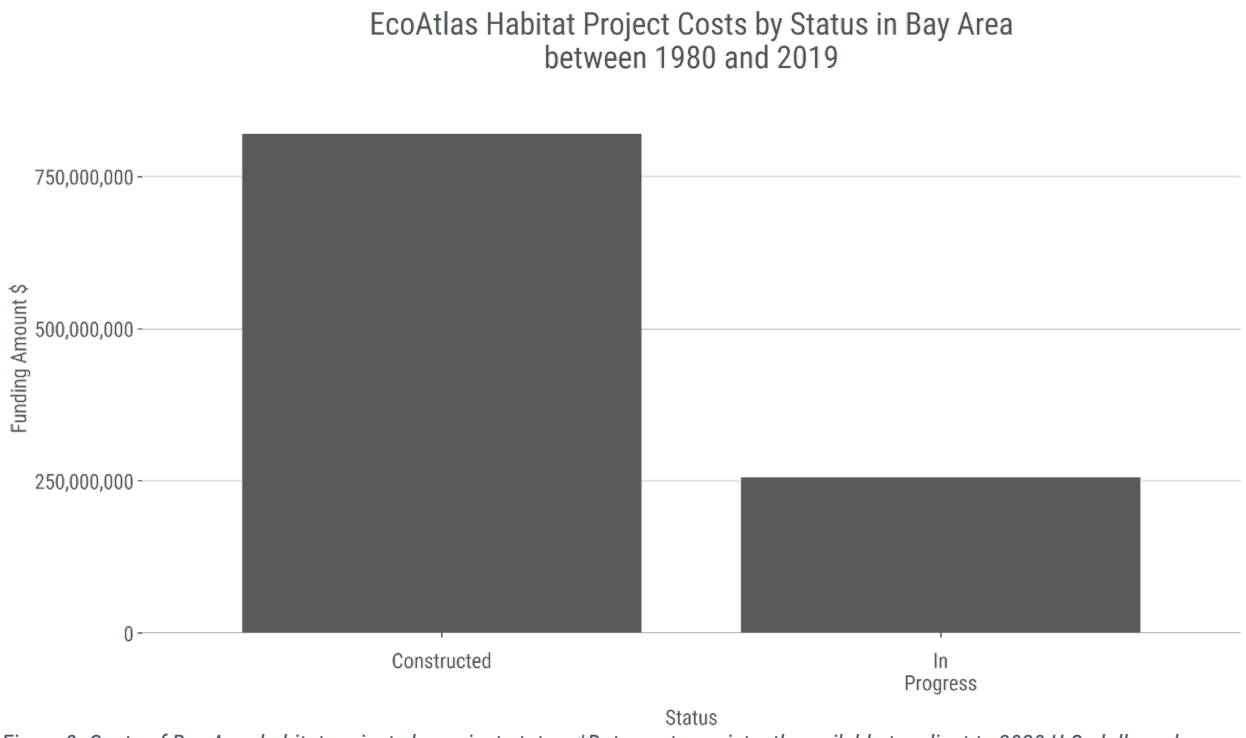

*Figure 8. Costs of Bay Area habitat projects by project status. *Dates not consistently available to adjust to 2020 U.S. dollar values.*

What is important to remember when looking at standardized costs is that they do not account for special site conditions. Environmental remediation can add magnitudes to the original cost estimates. Complex construction conditions such as in a highly developed area like the San Francisco Waterfront will also add magnitudes. Additionally, other regional hazards can also exacerbate costs. For example, the San Francisco Embarcadero Seawall, which includes a seismic retrofit in addition to its difficult urban placement with complicated intersecting infrastructure, comes in at approximately $86,500 per linear foot, or almost thirteen times as much as the high end of AECOM's sea wall estimate.

We arrived at another linear foot estimate using nine adaptation projects provided by San Francisco Bay Regional Coastal Hazards Adaptation Resiliency Group

Table 4. AECOM Cost Estimate Ranges for different SLR Adaptation Strategies in the Bay Area (2019 USD).

Strategy Typology:	**Low Cost Estimate per LF:**	**High Cost Estimate per LF:**
Traditional Levee	$800	$3,520
Seawall	$3,870	$6,800
Horizontal Levee	$2,300	$5,800

(CHARG)[1] by dividing project design costs by each project's linear footprint (see Figure 9). These projects vary in the type of shoreline protection they use.

The analysis results in a median range of about $2,600 - $5,250 per linear foot for currently underway or planned adaptation projects in the Bay Area. This range is comparable to AECOM's engineering estimates for horizontal levees and seawalls, but higher than traditional levees, potentially due to the inclusion of additional project costs such as environmental mitigation, land acquisition and easements and utility relocation.

When looking at the average instead of the median range, the cost balloons to $15,500 -$27,700 per linear foot due to the larger and often more uncertain cost estimates of projects such as the San Francisco Airport, Dumbarton, SR-37 and the San Francisco Sea Wall.

Individual Bay Area Adaptation Projects (Case Studies)

Comparing current individual Bay Area adaptation projects, including both those in conceptual phases and in design planning, shows greatly varying project costs based on size and location (see Figure 10), and even when adjusting for shoreline length (see Figure 9). They also differ in flood protection targets, with some projects aiming for FEMA accreditation, which covers current storm flooding (for protection under the National Flood Insurance Program) and others for protection from higher SLR scenarios. Not building to similar standards may pose long-term regional risks to the region because water knows no jurisdictional boundaries—if a neighboring city builds to a lower flood protection standard, that could put its neighbors at risk. See the Appendix for short profiles of larger Bay Area adaptation projects including their name, SLR flood protection targets, and total cost estimates.

Project Cost Unknowns

This section touches on some of the unknown project costs related to flood adaptation, but is not an exhaustive list. The costs of multi-hazard adaptation, such as seismic safety and stormwater management as well as asset-specific adaptation for large, critical infrastructure projects such as the region's ports and airports require their own analysis and discussion.

Adapting to Groundwater Rise

Most adaptation cost estimates for the region are for the cost of building linear protection along the shoreline to protect the land from the Bay. With groundwater rise, flooding would occur from below, meaning traditional overland flood barriers, such as levees, would do nothing to stop the upward rise of water from the ground. Subsurface barriers and pumps would be added costs not currently integrated into many adaptation projects nor projections of costs. In addition, contamination in the soil could be mobilized through rising groundwater levels and affect groundwater quality and enter communities.

Cost of Fill for Adaptation Projects

Fill has many issues that increase the cost of adaptation projects. One issue is that fill is extremely expensive to move around in large volumes and has no stockpiling locations close to shoreline projects, making it one of the highest costs in many adaptation projects. There are also strict regulatory requirements on the quality of beneficially reused soil. Additionally, there is a lack of affordable and accessible stockpiling locations in the Bay Area for large quantities of soil.

Cost of Dredging for Beneficial Reuse

Adaptation measures that use dredged sediment must ensure the sediment quality is appropriate for the use. Sediment dredged for navigation purposes represents a ready supply of fine grain sediment that works well for wetland restoration projects. There are a limited number of navigation dredging projects that produce

1 "Sea Level Rise Resiliency Map – San Francisco Bay Regional CHARG."

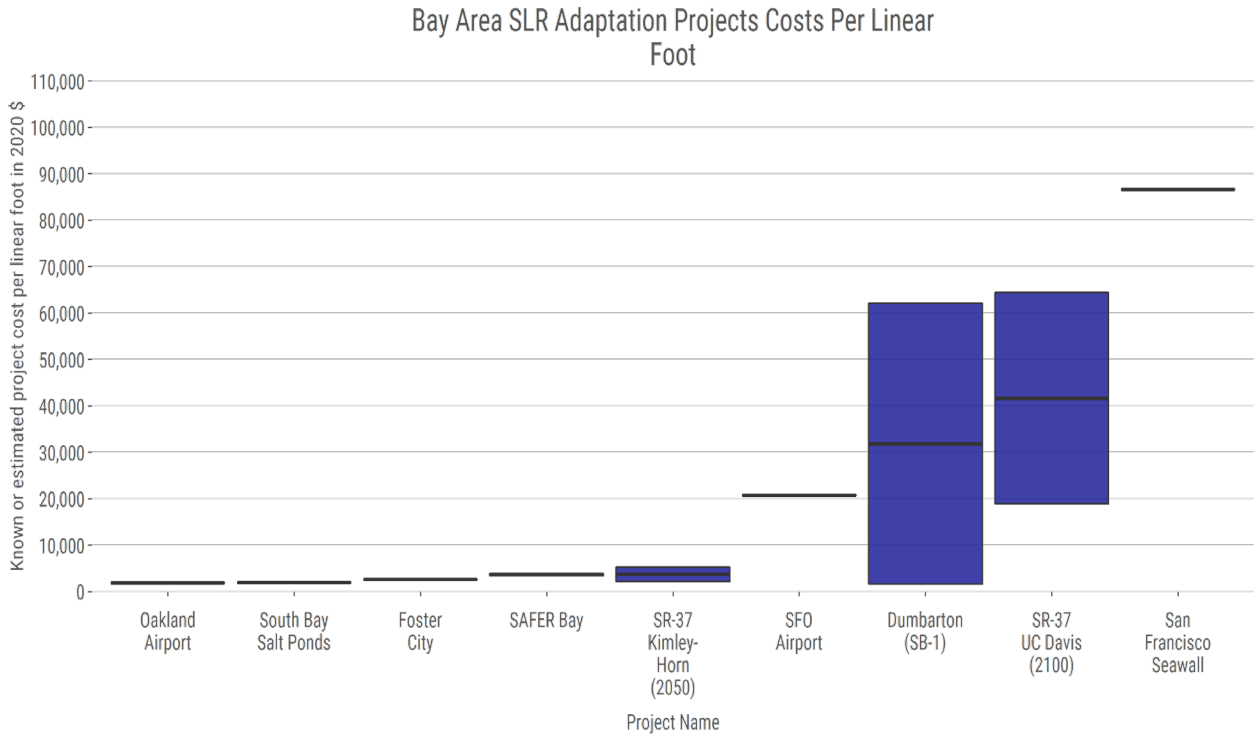

Figure 9. Costs of Bay Area sea level rise adaptation projects per linear foot of project footprint extracted from the CHARG Sea Level Rise (SLR) Resiliency Map.[1] Project lengths for Hayward and Oro Loma infrastructure were not available in the CHARG dataset at time of analysis.

1 "Sea Level Rise Resiliency Map – San Francisco Bay Regional CHARG."

sandy sediments rather than mud. As a result, much of the beneficial reuse of dredged sediment – over 25 million cubic yards since 2000—has been used at seven wetland restoration sites. The use of dredged sediment in these projects has been to fill deeply subsided baylands to elevations suitable for quick colonization of marsh vegetation, which in turn provides habitat, a place for flood waters to be absorbed, and attenuation of waves generated on the shoreline. When dredged sediment is not beneficially reused, it is treated as a waste product and disposed aquatically, either at dispersive deep in-bay disposal sites or 50 miles out to sea at a deep ocean disposal site. In these instances, the sediment is unlikely to support adaptation to rising seas either through natural sedimentation at existing or restored marshes.

While navigation dredged sediment is readily available and can be delivered in large quantities – 4,000 to 6,000 cubic yards at a time compared to 10 cubic yard dump trucks--there are other costs that need to be considered. Currently the dredging project sponsor pays both for the dredging and the disposal or placement of the dredged sediment. Aquatic disposal, particularly in-Bay disposal, is the cheapest method of disposing of the sediment. Ocean disposal can be similar in cost, or slightly to significantly less expensive than beneficial reuse. When a project places dredged sediment at a beneficial reuse site, the dredging project sponsor incurs what is known as the incidental cost of beneficial reuse. This incidental cost consists of additional transportation time, any tipping fees charged by a restoration site, and the cost of bringing an offloader, if individually provided by the contractor. For the US Army Corps of Engineers (USACE), providing the funding for the incidental cost has been a challenge due to an internal policy known as the federal standard. The USACE has stated that it will beneficially reuse its dredged sediment if that site represents the least cost alternative, is required

by a federal agency (i.e., the Federal Endangered Species Act) or if another entity provides the additional funds. If the USACE took all of its navigation dredged sediment to beneficial reuse sites an additional 1 to 1.5 million cubic yards of sediment could be provided to restoration and adaptation projects, as the USACE is the largest dredger in the Bay and the volume of sediment it produces far exceeds others in the dredging community.

Regarding the receiving site, additional funding is needed, particularly for restoration projects working with limited budgets to prepare sites for sediment delivery and management. The ideal beneficial reuse site has subsided areas that need significant volumes of sediment to create the economies of scale needed to offset the challenges. Dredged sediment generally needs to be pumped off of nearby barges to the site. This entails offloading equipment, pipes, and either electricity or diesel to power the equipment. The sediment must be slurried (mixed with water – generally 20% sediment to 80% Bay water) to pump it to the site. Once on the site, the slurried sediment is allowed to settle out of the water on site, and then the water is either discharged back to the Bay or held on site. In either case, water management must be incorporated. In some sites, the additional water management requires containment cells or raising existing levees to contain the water. These considerations mean that additional planning, site preparation, and management must be built into the project construction design and sequencing. As described, the project complexity is increased at the outset of the project but has shortened the time needed for wetlands to fully develop by 30 to 40 years, thus providing adaptation benefits much sooner than waiting for sediment to be naturally delivered.

Timing of Project Costs

Adaptation projects around the bay will likely be built slowly over time rather than all at once. Additionally, as sea levels rise, existing shoreline protection infrastructure may be modified to expand its lifespan and provide protection at higher sea levels. This creates an unknown in being able to correctly predict annual project costs over time on a regional scale.

Construction Costs

Construction costs might change over time if the industry can train and retain a skilled workforce for building green and natural infrastructure. Additionally, regulations regarding construction processes may be adding additional burden, costing time and money, and making projects more challenging, infeasible, or limiting innovative project types.

Cost of Environmental Permits and Regulations

Permitting for shoreline adaptation projects is a quagmire of requirements from different agencies that derive from different authorities and may not have formal mechanisms for coordination, creating sometimes conflicting requirements as well as complex and time-consuming permitting processes. Currently, the permitting process for complex, multi-benefit projects is burdensome in terms of cost, and time and not always successful. The more complex a project, the longer the regulatory timeline. Looking long-term, the newly formed multi-agency San Francisco Bay Restoration Regulatory Integration Team (BRRIT) may eventually take on adaptation projects in addition to wetland restoration projects, increasing the viability of adaptation projects and reducing costs due to regulatory agencies working together.

Disproportionate Costs of Environmental Injustice on Disadvantaged Communities and Federal Funding Formulas

When it comes to the costs of adaptation, disadvantaged communities face environmental injustice due to sea level rise. As already mentioned, many low-income communities are in low-lying areas adjacent to hazardous waste sites. This means the cost of adaptation projects in these areas may be much higher due to the environmental remediation costs, which can add millions to projects. Additionally,

hazardous waste sites and/or landfills are not designed to be permanently submerged, meaning many sites that are considered "cleaned" may need further remediation. To place these cost burdens on vulnerable communities is to further environmental injustice in the Bay Area.

Low-income communities also do not have the level of public and private investment that will produce the level of flood-induced economic damages required to compete for federal funding using a strict benefit-cost ratio approach. Congress and the White House – including the Office of Management and Budget – should revise federal benefit-cost requirements with a specific equity focus that will enable disadvantaged communities to compete for funding from the U.S. Army Corps of Engineers and the Federal Emergency Management Agency, among others. There is progress on this front: Section 110 of the Water Resources Development Act of 2020 directs the U.S. Army Corps of Engineers to issue final agency procedures for the Principles, Requirements, and Guidelines (PR&G) which will allow the Corps to fully identify the national, regional, environmental, and societal benefits of future water resources development projects.

Funding Supply: Funding for Adaptation Projects

This section explores federal, state, regional and local funding opportunities and provides an understanding of magnitude available for resilience. It also considers funding sources not specifically designated for resilience, but parts of which may be re-appropriated for adaptation.

It is not always clear to communities who is "on the hook" for paying for adaptation – instead, funding for adaptation projects will have to come from a variety of sources. In addition, it is not just funding streams earmarked specifically for adaptation that will be utilized, but funding currently used for a wide variety of city and county projects will need to incorporate resilience as a major component of project planning and implementation costs. For instance, new transportation projects in the future floodplain will need to examine raised streets, bridges and transit facilities and new wastewater and stormwater management infrastructure will need to navigate higher shorelines and discharge to higher total water levels in the Bay.

Incorporating resilience improvements to future capital projects that will be funded by some of existing local, state, and funds will be a likely strategy for closing the cost gap, in addition to generating new sources through new taxes and fees. However, creating new taxes and fees to fund sea level rise adaptation projects faces challenges in California, discussed in more detail later in this section. Novel solutions such as risk funding through insurance could provide additional resources.

Some adaptation solutions could deepen inequity and increase vulnerabilities for low-income communities. When considering funding and financing strategies, equity needs to be intentional, explicit, and embedded across adaptation outcomes. Funding strategies that do not consider how costs will be transferred to lower-income communities will further the systematic inequities created by the planning community throughout U.S. history. While this paper does not focus on analyzing individual financing tools, this is an important point to note for the region when deciding how to fund and finance these shoreline projects equitably.

Federal Funding

Federal funds currently play a large role in planning and building infrastructure projects and in local economic development. For example, the Water Resources Development Act (passed on average every 2 years) authorizes and appropriates funding for U.S. Army Corps of Engineers to work with local partners to study, build, and operate and maintain Civil Works projects. FEMA funds resilience through a number of mitigation and recovery programs, including Building Resilient Infrastructure and Communities (BRIC). Community Development Block Grants (CDBG) from the U.S. Department of Housing and Development (HUD) are also a potential source of funding. These and other existing funding sources will likely play a significant role in adaptation funding.

Adaptation-Specific Federal Funding

U.S. Army Corps of Engineers (USACE) and the Water Resources Development Act

The U.S. Army Corps of Engineers ("USACE") are the nation's flood risk management experts. With funding authorized by Congress through the Water Resources Development Act, USACE works with communities to reduce risks in coastal areas and build resilience to coastal hazards through an integrated planning approach.

USACE has a number of mission areas authorized by Congress that intersect with flood risk management and protection of ecosystems[1], including the Civil Works Flood Risk Management Program and Levee Safety Program.

1 https://www.usace.army.mil/Missions/

Typically, USACE commences potential flood risk management project planning after Congress authorizes a ***general investigation***. A general investigation is a $3 million, 3-year study to determine whether there is a federal interest in a federally-funded flood risk management project. This process uses a benefit cost ratio (BCR) to determine whether the benefits of the project outweigh the costs, and this is part of the definition of federal interest. As discussed elsewhere in this paper, Congress, the Assistant Secretary of the Army and USACE are all moving away from a strict economic BCR approach towards an approach that weighs regional, environmental, and social benefits of projects.

If result of the feasibility study demonstrates s a federal interest, the study process results in a recommendation by the Chief of Engineers to Congress to fund a flood risk management project. There are several major USACE studies underway in the Bay right now, including the South San Francisco Bay Shoreline Project and the San Francisco Waterfront Flood Resiliency Study.

After receiving an integrated Chief's report and recommendation, Congress authorizes funding for projects in a Water Resources Development Act (WRDA) and subsequently appropriates funding through Energy & Water Development bills, subject to a 1/3 local match requirement provided by local, non-federal partners. The upper bound for federal funding is limited only by the benefits (mainly avoided economic damages) that a project will produce. The strict economic BCR analysis and the local match requirement can be the barrier to receiving this type of funding for disadvantaged communities.

WRDA 2020 was passed as part of the December 2020 COVID-19 stimulus package, amending the Bay study authority for Marin, San Mateo and San Francisco counties to seek federal funding to combat sea level rise and increasing the annual funding for bay wetland restoration from $5 million to $9 million. As discussed above, WRDA 2020 changes the way the U.S. Army Corps calculates costs and benefits, which until now required balancing the economic benefits of adaptation against the full project budget, making it difficult for very expensive projects, such as the San Francisco Embarcadero Seawall, to compete for federal funds.[1]

National Security

The United States officially recognized resilience in the 2017 and 2021 "National Security Strategy," which states that we must enhance our resilience, including the ability to withstand and recover from deliberate attacks, accidents, natural disasters, as well as unconventional stresses, shocks and threats to our economy and democratic system. These strategies have directed efforts from both FEMA and the U.S. Department of Homeland Security (DHS).

FEMA

FEMA is one of the largest funders for adaptation through their Pre-Disaster Mitigation (PDM) Grants, Flood Mitigation Assistance (FMA) Program, and their Hazard Mitigation Grant Program (HMGP). The PDM and FMA both fund pre-disaster adaptation projects—in 2020 this amount totaled in $700 million nationally and, under the Biden administration, as much as $10 billion could be made available for climate adaptation[2].

The PDM Grant Program has been replaced with the Building Resilient Infrastructure and Communities (BRIC), which is designed to assist in pre-disaster natural hazard mitigation to reduce overall risk from future hazard events while also reducing reliance on federal funding for future disasters. In 2017, $90 million was available nationally through PDM grants, and in 2020, $500 million was available through the BRIC this program—a clear indication that the U.S. is taking pre-disaster mitigation seriously by increasing the funds available before a disaster.

The FMA Program has the goal of reducing or

1 "S.F.'s Embarcadero Seawall Is Surprise Beneficiary of Trump-Signed Spending Bill."
2 https://www.nytimes.com/2021/01/25/climate/fema-climate-spending-biden.html

eliminating insurance claims under the National Flood Insurance Program (NFIP). In 2017 there was $160 million available nationally—for 2020 there was $200 million.

The key purpose of HMGP is to ensure that critical mitigation measures to reduce the risk of loss of life and property from future disasters are included during the reconstruction process following a disaster. The amount of HMGP funding available to the applicant is based upon the estimated total federal assistance to be provided by FEMA for disaster recovery under the Presidential major disaster declaration. In 2019 FEMA allocated around $90 million in resilience grants ($75 million from the BRIC program and $15 million from the HMGP program) to the Bay Area according to MTC's Revenue Assessment.

FEMA also uses a strict benefit-cost ratio that examines avoided economic damages. While this is one important measure of the benefits of flood risk reduction projects, FEMA – like USACE – should consider a more holistic approach to assessing projects benefits, particularly for disadvantaged communities.

Department of Homeland Security (DHS)

In 2020 there were eight DHS preparedness (pre-disaster) grant programs totaling nearly $1.8 billion. These grants include the Regional Resiliency Assessment Program (RRAP), which does regional planning for resilient infrastructure—for example, California's water systems in the Central Valley were analyzed for drought in 2016 and Southern California in 2017. These voluntary, non-regulatory RRAP projects are selected each year by the Department with input and guidance from federal, state, and local partners. They have focused on sectors such as Energy, Transportation Systems, Commercial Facilities, and Food and Agriculture. The goal of the RRAP is to generate greater understanding and action among public and private sector partners to improve the resilience of a region's critical infrastructure. Another preparedness grant is the Emergency Management Performance Grants, which will provide more than $355 million for 2020 to assist state, local, tribal, and territorial governments in enhancing and sustaining all-hazards emergency management capabilities. In 2020, the Urban Area Security Initiative (UASI) will provide $615 million to enhance regional preparedness and capabilities in 32 urban areas, with 25 percent of these funds going to terrorism prevention.

National Oceanic and Atmospheric Administration (NOAA)

The National Oceanic and Atmospheric Administration (NOAA) is also a big player in resilience funding. In 2019 NOAA's National Coastal Zone Management Program invested over $75 million, allocated through the Coastal Zone Management Act, to implement coastal management programs in the 34 participating states and territories. The federal funding was matched by nearly $63 million from state and local governments and other partners. These funds were used to improve public access, enhance hazard resilience, and fuel the nation's vibrant coastal economy. Two programs were used to address coastal hazards**:** Protecting and Restoring Coastal Habitat and Mitigating Coastal Hazards. These two programs were 40% of the annual budget, totaling $31.1 million in federal funds and $24.4 million in matching funds.[1]

The current NOAA grants for 2021 total in $248.1 million nationally. Besides funding projects, they also fund the science of climate change and coastal resilience. In 2021, $200 million of this money is to go to research institutes to investigate severe storms, with $1 million going towards environmental literacy for the Bay Area. The Climate Program Office is granting $7.6 million for investments in regionally scaled, interdisciplinary climate research and engagement on reducing vulnerability through climate knowledge.

1 Office for Coastal Management, National Oceanic and Atmospheric Administration, "NOAA's National Coastal Zone Management Program Funding Summary 2019."

National Fish and Wildlife Foundation (NFWF) & NOAA

In 2019, Congress funded the Supplemental Appropriations Act of 2019, allowing grants to be awarded through a partnership between the National Fish and Wildlife Foundation (NFWF) and NOAA. They launched the Emergency Coastal Resilience Fund two months later to direct this money to help impacted communities recover more quickly from and be more prepared for future disasters with a focus on strengthening natural systems. Congress provided funding for Title IX of the National Oceans and Coastal Security Act, allowing grants to be awarded through a partnership between NFWF, NOAA, Shell, and TransRe. These grants were then awarded through the National Coastal Resilience Fund.

NFWF and NOAA partnered to deliver $43 million in grants to improve the resilience of local communities and wildlife habitat in the face of increasingly severe and frequent natural disasters. The grants supported natural and nature-based infrastructure for people and wildlife to recover from hurricanes Michael and Florence, Typhoon Yutu, and the California coastal wildfires of 2018, and be better prepared for future events. In 2019, 44 new grants from the National Coastal Resilience Fund were awarded totaling $29.3 million and generated $60 million in matching funds from the grantees, providing a total conservation impact of $89.3 million. In the Bay Area, this helped fund the Lower Walnut Creek Restoration ($1.4 million in grants) and Marin City wetlands ($146k in grants).

U.S. Environmental Protection Agency

Another big national adaptation funding player is the U.S. Environmental Protection Agency (EPA). Included in this is the San Francisco Bay Water Quality Improvement Fund, whose budget is determined by congressional appropriation each year. In 2017 there was $4.3 million and available funding has been about $5 million per year. Water quality projects can help reduce flooding through green infrastructure and can also include wetland creation. The EPA's State Wetlands Planning program has grants of $700k per year. The EPA's Brownfield and Environmental Justice grants could help remediate contaminated shoreline land—a major issue for environmental justice concerns, as well as directly support community-based organizations. For 2020, the EPA funded 155 Brownfield grants nationwide at a total of $65.6 million. Environmental Justice grants for 2020 totaled at $3.7 million.

Bay Area Federal Funding Data

One major source of general (i.e., not adaptation-specific) funding for jurisdictions comes from federal grants, such as HUD's CDBGs mentioned earlier. The Federal Government plays a large role in distributing funds, which can be seen in Table 4 and Figure 12. This section explores data from the State Controller's Office, which was analyzed for federal revenues from Community Development Block Grants, Workforce Investment Act, and other federal grants. Note that one reason that federal funding examined in this section skews towards San Francisco is that San Francisco is also a County and is the largest regional producer of affordable housing and provider of services for unhoused residents in the region.

However, Federal Government spending vary from year to year and decade to decade depending on the political party in office and national trends (see Figure 11). Federal spending is at an all-time low compared to the previous 90 years. These federal spending trends play a huge role in the availability of funds for adaptation projects.

As seen in Figure 12, federal funds are not equally distributed to cities around the Bay. For the reasons described above, San Francisco received about $500 per capita from the Federal Government annually between 2017 to 2019, or about 60% of the federal revenue for the entire Bay, while many other cities received little to no funds due to several factors such as a lack of resources to apply for grants or lack of interest in pursuing funds due to their designated purposes.

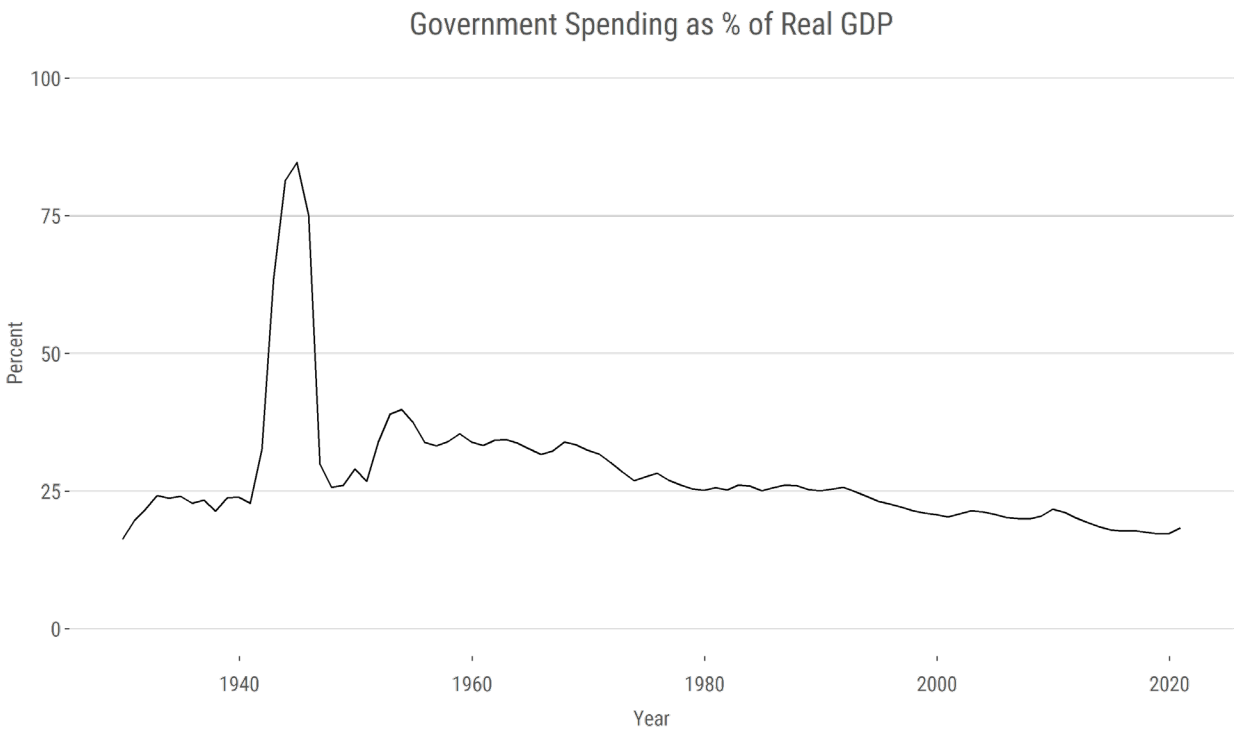

Figure 11. National Federal Government spending as percentage of national GDP (Data Source: U.S. Bureau of Economic Analysis (BEA)).

Table 5. Mean annual federal revenue received in the Bay Area per city between 2017-2019 (Data Source: State Controller's Office).

	Revenue	**Revenue per capita**
Regional Total	$ 720.7 million	$ 96 / capita
Regional Mean by City	$ 7.1 million	$ 39 / capita
Regional Median by City	$ 0.48 million	$ 16 / capita
Regional Maximum by City*	$ 435.7 million	$ 498 / capita

**The regional maximum was in San Francisco*

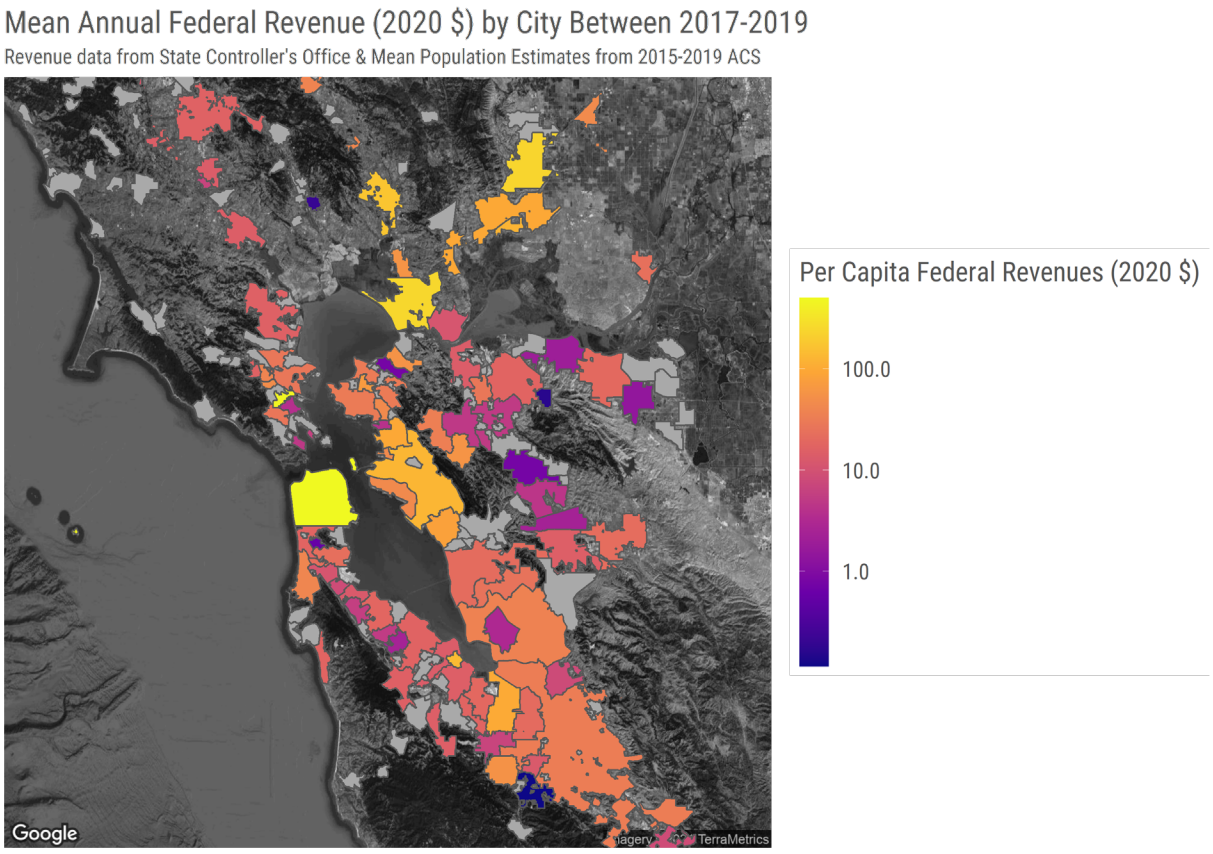

Figure 12. This map shows how mean annual per capita federal revenue was distributed to cities around the Bay between 2017-2019, with yellow being the highest and blue being the lowest. These Federal revenues include Community Development Block Grants (CDBGs), Workforce Investment Act (WIA), and 'other' Federal grants.

State Funding

Adaptation-Specific Funding

State Propositions

There are several bills that have been passed in California that address funding for adaptation. These include the following:

- **Proposition (Prop.) 1** authorized $7.5 billion in general obligation bonds for water projects including surface and groundwater storage, ecosystem and watershed protection and restoration, and drinking water protection. This includes $1.5 billion for competitive grants for multi-benefit ecosystem and watershed protection and restoration projects, as well as $395 million for statewide flood management projects and activities.
- **SB-1** is a 2017 transportation bill that provides up to $20 million to local and regional agencies for climate change adaptation planning. SB-1 increased existing fuel taxes and created two new vehicle fees. The total bill includes $54 billion over the next decade.
- **Prop. 84** authorized $5.4 billion in 2006 for general obligation bonds for water and flood control projects.
- **Prop. 68** passed in 2018 and is for state and local parks, environmental protection and restoration projects, water infrastructure projects, and flood protection projects, opening up $4 billion in general obligation bonds.
- **AB-398** extended California's Cap and Trade program to 2030 for market-based compliance of climate change mitigation. AB-32 was the

establishing state law that started the program. It creates revenues of about $2 billion a year and includes prioritizing funding for climate adaptation and resiliency.

- **AB-733** expands the types of projects that can be funded with enhanced infrastructure financing districts to include projects that enable communities to adapt to the impacts of climate change.
- **AB-78**, passed in 2020, creates the Climate Catalyst Revolving Loan Fund that furthers California's climate goals, activities that reduce climate risk, and the implementation of low-carbon technology and infrastructure.
- **SB-667** authorized the California Department of Water Resources (DWR) to create the Riverine Stewardship Program for watershed-based riverine and riparian stewardship improvements.
- **AB-2800** requires state agencies to take climate change into consideration when building state infrastructure.
- **AB-109** provided $20 million to the Wildlife Conservation Board for local assistance, payable from the Greenhouse Gas Reduction Fund from Cap and Trade.

In Fall of 2021 the California passed a Climate Resilience Package. "Focusing on vulnerable front-line communities. The package includes $3.7 billion over three years to build resilience against the state's multi-faceted climate risks, including extreme heat and sea level rise." At the time of writing many unknowns remain about the exact distrubtion and use of these funds.

There are a number of potential sea level rise adaptation bills introduced in 2021, many directly addressing sea level rise funding such as SB-45, the Wildfire Prevention, Safe Drinking Water, Drought Preparation, and Flood Protection Bond Act of 2020.

Grants

Statewide, California has several grants dedicated to adaptation funding. A lot of these grants are geared towards nature-based adaptation such as wetland restoration and water quality improvement, and transportation. Many of these grants were made possible by the above bills.

California Department of Transportation (Caltrans)

The California Department of Transportation (Caltrans) is one of the largest players for state adaptation grants, although funded projects must include transportation elements. Their Sustainable Transportation Planning Grant Program helped fund 77 projects in 2020 totaling in $21.5 million to further the Sustainable Communities Strategy. For 2021, The Sustainable Transportation Planning Grant Program includes $29.5 million of funding for the Sustainable Communities Grants which will encourage local and regional planning that furthers state climate goals. Caltrans also provides Adaptation Planning Grants, which includes $20 million per year over three years, which ended in 2020. Much of this was funded by the SB-1 Transportation Improvement Fee, which creates $5 billion per year in revenue.

California Department of Water Resources (DWR)

Prop. 1 from the California Department of Water Resources (DWR) provides grants for flood improvements for water quality. DWR also funds the Riverine Stewardship Program, which runs the Urban Streams Restoration Program. In 2019 the program had $6.6 million for the state, and the Bay Area received $1.5 million of that.

The California Water Resources Control Board also uses Prop. 1 funds to administer funds for five programs. They provide $200 million for multi-benefit storm water management projects. This can include green infrastructure, rainwater, and storm water capture projects and storm water treatment facilities.

California Department of Fish and Wildlife

The California Department of Fish and Wildlife is

another big player for ecosystem restoration and offered $15 million statewide in 2019 for wetland restoration. These wetland restoration grants are from the state's Cap and Trade program.

California Ocean Protection Council

The California Ocean Protection Council (OPC) administers the Prop 68, Prop. 84 and Prop. 1 competitive grant programs. Prop. 1 is used for climate change adaptation, storm water recapture, wetland and coastal watershed restoration, marine managed area protection, fisheries infrastructure, and improvement of ocean water quality. Prop. 84 is used for addressing ocean acidification, sustainable fisheries and aquaculture, coastal sediment management, and marine pollution. In 2019 there was $9.3 million made available.

California State Coastal Conservancy

The California Coastal Conservancy funds a variety of adaptation and resiliency projects across its existing programs, as well as through dedicated bond measures. Conservancy projects funded through Prop. 1 provide more reliable water supplies, restore important species and habitat, and develop a more resilient and sustainably managed water system (water supply, water quality, flood protection, and environment) that can better withstand inevitable and unforeseen pressures in the coming decades. The Funds are administered through the Bay Area Integrated Regional Water Management Program. There was $7.12 billion made available in general obligation bonds for state water supply infrastructure projects (with specific budget breakdowns for certain water projects).

The Coastal Conservancy also runs the Climate Ready Program to help natural resources and communities along the coast and San Francisco Bay adapt to the impacts of climate change. This program has been funded by the Greenhouse Gas Reduction Fund from the Cap-and-Trade program as well as other sources. Through the Climate Ready Program, over $12 million has been awarded for 62 projects in from 2013 to 2019.

The Climate Ready Program did not have dedicated funding for new projects in 2020. Past projects have focused on sea level rise adaptation planning, nature-based infrastructure, carbon sequestration and urban greening.

California Wildlife Conservation Board

The California Wildlife Conservation Board (WCB) has Climate Adaptation Environmental Restoration grants that include funding for planning, technical assistance, and acquiring conservation easements. This grant priorities the protection of lands that facilitate wildlife adaptation to projected climate impacts by providing transitional habitat features such as elevation gradients and ecotones, and habitat linkages that enable wildlife movement to and from adjacent wildlife corridors and open space areas. It also is intended to fund projects that provide climate adaptation and resilience on California's natural and working lands. WCB released the first grant under this program in 2018, leading to nearly $12 million in grant funding to selected projects. The remaining $8 million will go to other qualifying projects in 2021. Future grant opportunities under this program may be funded through a similar legislative action, or another funding source.

Bay Area State Funding Data

A major source of non-resilience funding for cities comes from state grants and taxes, such as the Homeowners Property Tax Relief, Gasoline Tax, Off-Highway Motor Vehicle In-Lieu Fee, and Prop. 172, among other state grants. Like federal grants, state revenue is not distributed equally throughout the region, which can be seen in Table 2 and Figure 13. Even when accounting for population size, the East Bay and San Francisco receive the most per capita state revenue. San Francisco received about $1,060 per capita from the state government annually from 2017 to 2019 as compared to the $85 mean by city for the region as a whole.

Table 6. Mean annual state revenue received in the Bay Area per city between 2017-2019 (Data Source: State Controller's Office).

	Revenue	**Revenue per capita**
Regional Total	$ 1,361 million	$ 181 / capita
Regional Mean by City	$ 13.5 million	$ 85 / capita
Regional Median by City	$ 2.1 million	$ 60 / capita
Regional Maximum by City*	$ 923.8 million	$ 1,056 / capita

**The regional maximum was in San Francisco*

Bay Area Regional Funding Data

Measure AA

San Francisco Bay Restoration Authority's Measure AA introduced a $12 annual parcel tax for 20 years to fund Bay Area habitat restoration projects. This totals $500 million, or $25 million a year for 20 years before automatically expiring in 2037. While Measure AA is successful in helping to protect and restore the Bay, when looking at the scale of adaptation projects needed to protect the region from SLR, the $500M from Measure AA represents just 3% of this $19 billion in adaptation costs for 2 feet of SLR. Measure AA showed the region that citizens care about restoring and conserving the Bay's environment, but we need more aggressive funding measures to make an impact.

A complicating matter is that wetland restoration projects need to stand the test of time, as many wetlands will be drowned within the first foot of SLR if they are not maintained with regular sediment deposits to keep up with the rising tides. Measure AA funds currently do not fund long-term wetland project monitoring, just construction, meaning we will not be able to properly learn from many of these pilot projects without additional funding. When dealing with limited funding, it is incredibly important to use these funds strategically. We need more flexible measures that allow funds to be distributed where and how they are needed. A regional funding strategy could hold the birds eye view to understand the scale of adaptation costs and how funds could best be used.

City Funding

Using Existing Resources to Build Resilience into Capital Plans

In addition to federal and state grants, a significant source of SLR adaptation funding will inevitably be existing municipal revenue streams. It is inevitable that costs will need to be shared across all scales, including cities themselves. Generally, the limited amount of municipal revenue available is highly competitive with other important uses, such as schools, social services, or public transit. Municipalities need to use existing funds to build resilience into city capital plans, and may also need to add additional revenue streams through new fees or taxes, which has its own barriers and challenges. An additional challenge for municipal funding is that there are many financial and institutional barriers to mixing general funds and enterprise funds to conceptualize, plan, and execute integrated planning efforts with multiple resilience benefits.

Existing revenues can be slightly reallocated to incorporate adaptation into existing projects and services. Cities can task their transportation, planning, and public works divisions to incorporate adaptation into all projects using existing funds for these sectors. This could include projects such as ensuring new roads are built out of the SLR inundation zone or storm-proofing newly built sewer discharge pipes to allow water to drain even with rising waters. However, will existing revenues be adequate and flexible enough to pay for the adaptation needed? The answer is almost certainly not.

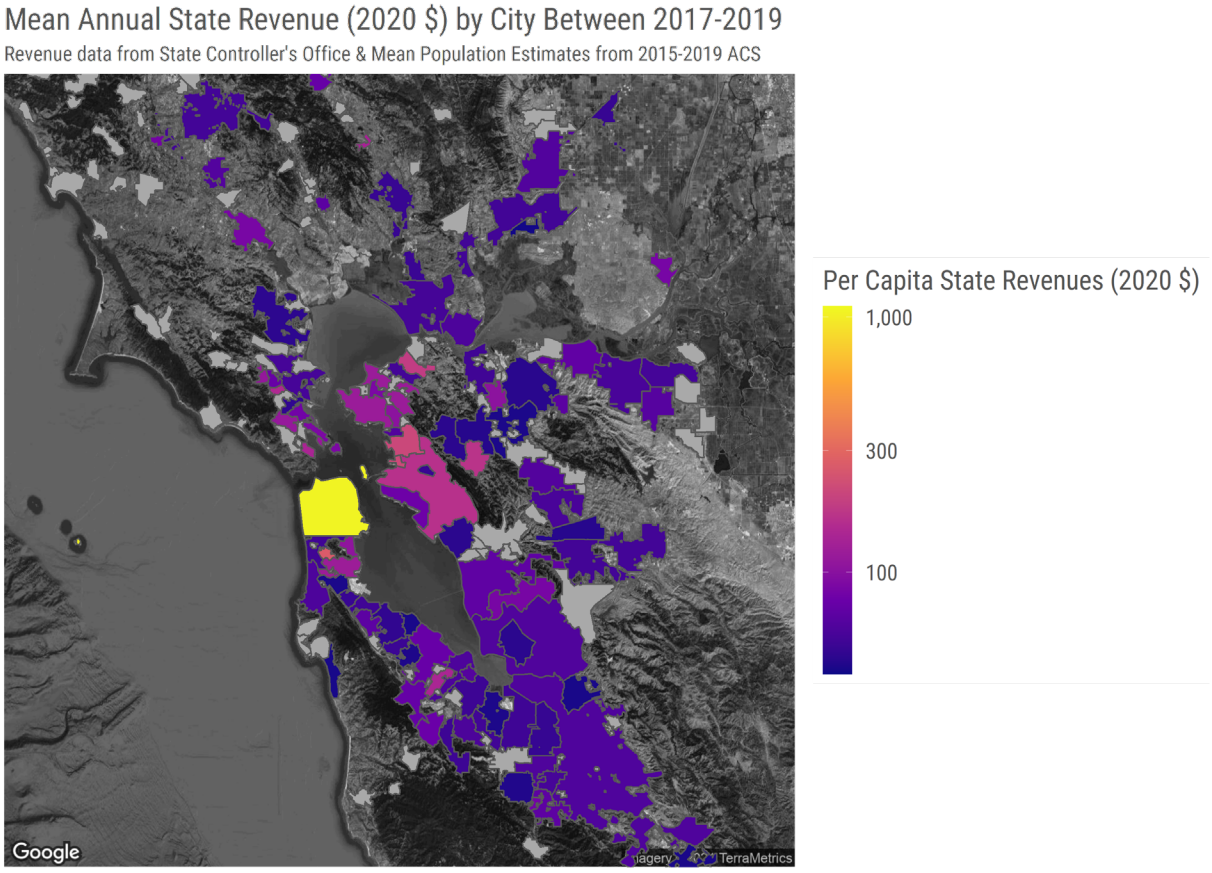

Figure 13. This map shows how mean annual per capita state revenues were distributed to cities around the Bay between 2017-2019, with yellow being the highest and blue being the lowest. These State revenues include Homeowners Property Tax Relief, Gasoline Tax (Functional Revenues), Peace Officers Standards and Training (Functional Revenues), Off-Highway Motor Vehicle In-Lieu Fee (General Revenues), Other Intergovernmental – State 1, 2 (General Revenues), Mandated Cost (General Revenues), Public Safety – Prop. 172 (Functional Revenues), Public Safety – 2011 (Functional Revenues), Other State Grants – Other (Specify) (Functional Revenues).

To estimate baseline city expenditure, we used the SCO's data on capital outlay, defined as expenditures used to acquire or construct capital facilities financed by a governmental fund, typically a capital projects fund, and debt service, defined as principal or interest payments on debts from General Obligation Bonds, Revenue Bonds, Certificates of Participation, Pension Obligation Bonds, construction financing, and other agency debt.

There is a large variance in public expenditure among Bay Area Cities. The three largest cities by population and expenditure—San Francisco, San Jose, and Oakland—make up 56% of total spending between the years 2017 and 2019. When adjusting for population, the per capita expenditure shows a less drastic split, with smaller jurisdictions such as Colma, Half Moon Bay and Mill Valley having the highest average annual expenditures in these three years (see Table 6 and Figure 14). Overall, the per capita expenditure throughout the Bay Area varies greatly as can be seen in Figure 14. This presents unique challenges and opportunities for sea level rise adaptation as cities rely on their neighbors for adequate protection of communities and important assets. ART Bay Area identified hotspots that show many vulnerable spots outside of these high expenditure areas that will need significant outside investment to protect vulnerable communities, habitats, jobs, and transportation networks that the Bay Area as a region relies on.

Table 7. Mean annual city expenditures in the Bay Area per city between 2017-2019 (Data Source: State Controller's Office).

	Expenditure	Expenditure per capita
Regional Total	$ 2.5 billion	$ 338 / capita
Regional Mean by City	$ 25.1 million	$ 340 / capita
Regional Median by City	$ 7.5 million	$ 235 / capita
Regional Maximum by City	$ 814 million*	$ 3,783 / capita**

**The regional total maximum expenditure was in San Francisco*
***The regional maximum per capita expenditure was in Colma*

Creating New Funding Streams

Inherently, some cities can raise more money than others based on property tax revenues from homes and businesses. The Bay Area contains some of the most expensive real estate in the country, while other areas suffer from disinvestment. Finally, just because a city has revenue does not mean that they have the local capacity to plan, manage, build, and maintain adaptation projects, particularly for adaptation projects that need to occur in phases over time.

There are many resources available to local governments that are interested in generating new local funding for capital projects. The California Debt and Investment Advisory Commission, a division of the California Treasurer's Office, publishes the California Debt Financing Guide[1]. Another resource is the 2017 Guide to Local Government Finance in California[2].

Affluent communities around the Bay can leverage high property values to finance coastal resilience – specifically those improvements that will protect property values. Many communities already use this source of funding to build and upgrade public school facilities, assisted by the carve out in the California Constitution that allows local communities to pass General Obligation (G.O.) Bonds with a 55% vote.

G.O. bonds approved by 2/3 of voters levy a surcharge on community-wide property taxes above the 1% property tax limitation imposed by Proposition 13. Community facility district bonds levy a surcharge – typically a per square foot charge – that is independent of property value. Infrastructure Financing Districts can be used to capture the local share of property tax growth from new development or reassessments over time.

Creating new city revenue streams to pay for adaptation is complicated due to two California Propositions that inhibit new tax revenues. Prop. 218, passed in 1996, prohibits property-related fees for general government services. This limits the funding stormwater utilities or flood districts can raise from users and is a huge hurdle for raising local funds for flooding-related projects. However, SB-231 was passed in 2017, which adds a definition to Prop. 218 that clarifies a "sewer" can include storm drainage. This now exempts stormwater from the voter approval requirement. This would enable municipalities to establish and increase stormwater fees by an action of the governing board (city council or board of supervisors) rather than by putting it to vote by the public. At face value, this appears to undo the damage of Prop. 218; however, the authors and proponents of Prop. 218 (Howard Jarvis Taxpayers Association) consider the new law to be unconstitutional and has promised to sue any agencies that move forward without voter approval.[3]

1 https://www.treasurer.ca.gov/cdiac/debtpubs/financing-guide.pdf
2 Coleman et al., Guide to Local Government Finance in California.
3 "Overview and Background | CASQA - California Stormwater Quality Association."

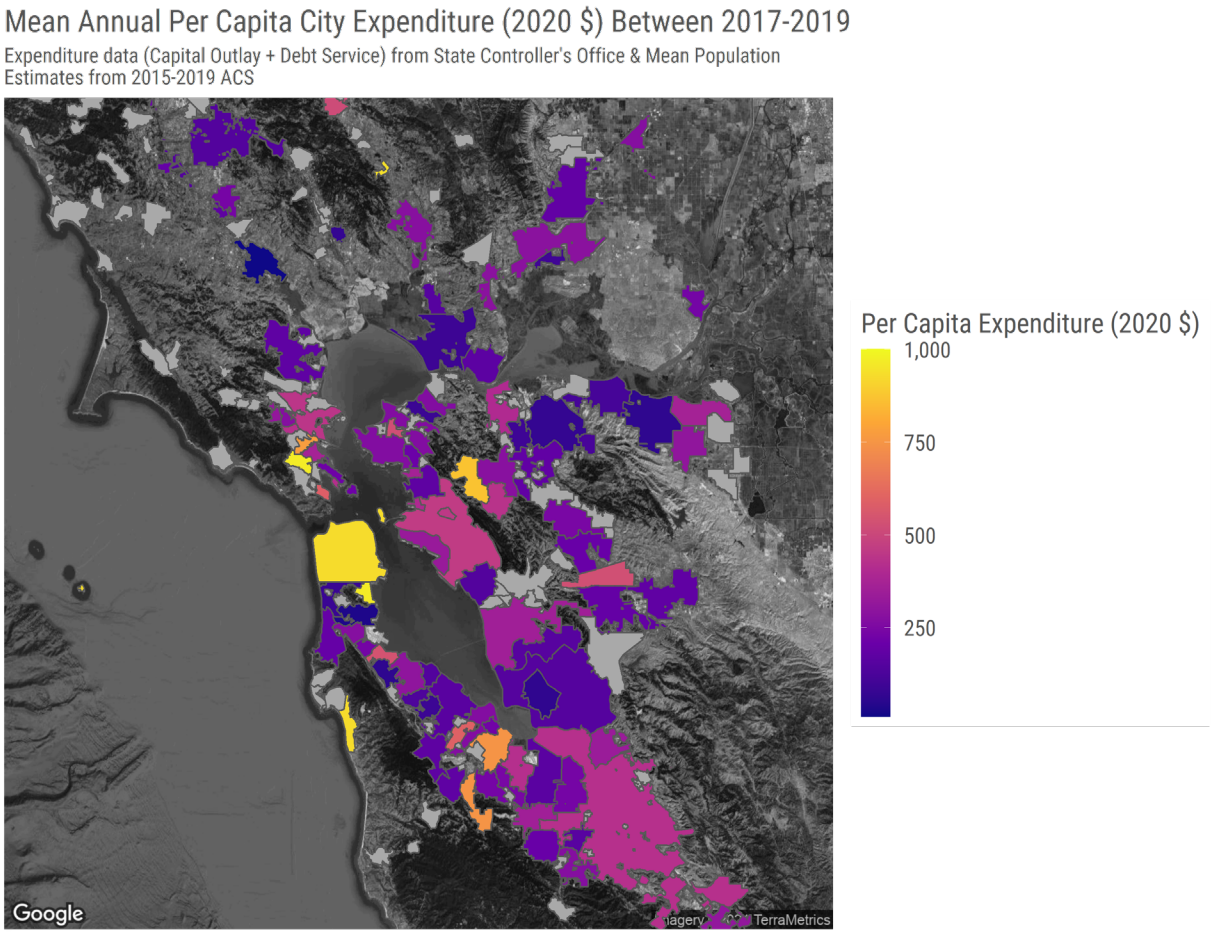

Figure 14. Map of the mean annual per capita city expenditure in 2020 USD for the years 2017-2019. Values above $1000 per capita truncated.

The second limitation is Prop. 13, which limits property tax to no more than 1% of a property's assessed value in 1976 and limits annual increases to inflation or 2%, whichever is lower. It also requires a two-thirds majority vote of the state legislature to increase non-property taxes and a two-thirds majority vote for local governments for any special taxes. This greatly limits the revenue cities can raise from property taxes even though the Bay Area has some of the highest property values in the nation (see Figure 15). Using the Zillow Typical Home Value, cities in San Mateo and Marin have a much higher home value than many other cities in the Bay Area, which one would think would put them in a better position for adaptation on a per capita basis. In June of 2020 the Zillow average house value by city and total household estimate from the American Community Survey (ACS) has the region at a total of $2.9 trillion in property value. However, given the limitations expressed above, it is more difficult to raise additional revenue from this nearly 3 trillion-dollar value.

Additionally, Prop. 26, passed in 2010, requires a two-thirds supermajority for new taxes, levies, charges, and fees. This makes any new funding measures very challenging to approve without proper public engagement and education.

Risk funding is an alternative for local and regional governments, and their communities, to pay for insurance and risk-reduction collectively through risk management structures that do not require new taxes or fees. Such programs offer the potential to supplement existing insurance alternatives and generate funds for collective risk reduction.

Case Study: San Francisco Office of Capital Planning and Resilience General Obligation Bond Program

Even with a 2/3 supermajority requirement, it is possible to gain the confidence of voters and develop new funding sources.

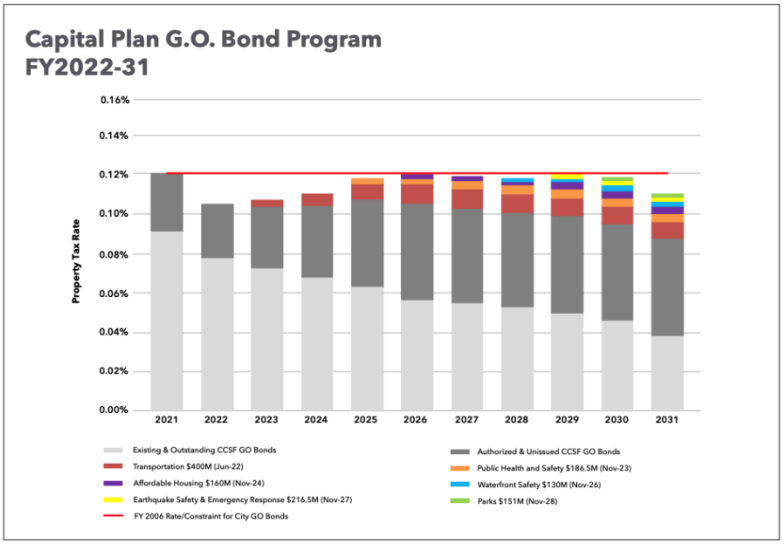

CHART 1.1

San Francisco has developed a structured process for planning, funding and implementing capital improvements with voter-approved G.O. Bonds, General Fund debt called Certificates of Participation (COPs), and revenue bonds. The process is managed through a transparent public process with recommendations generated by a Capital Planning Committee comprised of City department heads that reports to the Board of Supervisors and the Mayor. The G.O. Bond Program is also overseen by a Citizen's General Obligation Bond Oversight Committee.

TABLE 5.1

G.O. Bond Program
(Dollars in Millions)

Election Date	Bond Program	Amount
Jun 2022	Transportation	400
Nov 2023	Public Health	187
Nov 2024	Affordable Housing	160
Nov 2026	Waterfront Safety	130
Nov 2027	Earthquake Safety & Emergency Response	217
Nov 2028	Parks and Open Space	151
Nov 2031	Public Health	TBD
Total		**1,245**

G.O. Bonds are backed by San Francisco's property tax revenue and are repaid directly out of property taxes through a fund held by the Treasurer's Office. The Plan structures the G.O. Bond schedule around the notion of rotating bond programs across areas of capital need. San Francisco strives to maintain the same overall property tax rate by issuing new debt as old debt is retired and San Francisco's property tax base increases. Chart 1.1 from San Francisco's 2022-2031 10 Year Capital Plan[1] shows how San Francisco plans its debt issuances to remain below a stable tax rate (less than 1.2% of property value, with all City-imposed property tax overrides).

This combination of clear planning for capital investment and orderly issuance of debt in a manner that does not produce significant tax increases has resulted in a track record of consistently passing G.O. Bonds by more than the 2/3 voter approval requirement. Since adopting its Program, San Francisco voters have approved $5.5 billion in G.O. Bond funding for a variety of capital improvements, with voters approving 12 proposed G.O. Bond proposals consecutively.

In 2018, San Francisco voters approved a $425 million general obligation resilience bond in the form the Embarcadero Seawall Earthquake Safety Bond, which also funds sea level rise adaptation. Table 5.1 from San Francisco's 2022-2031 10 Year Capital Plan shows San Francisco's planned G.O. Bonds through 2031, including a new Waterfront Safety Bond estimated at $130 million planned in 2026.

In June of 2020 the Zillow average house value by

1 https://onesanfrancisco.org/Proposed-Plan-2022

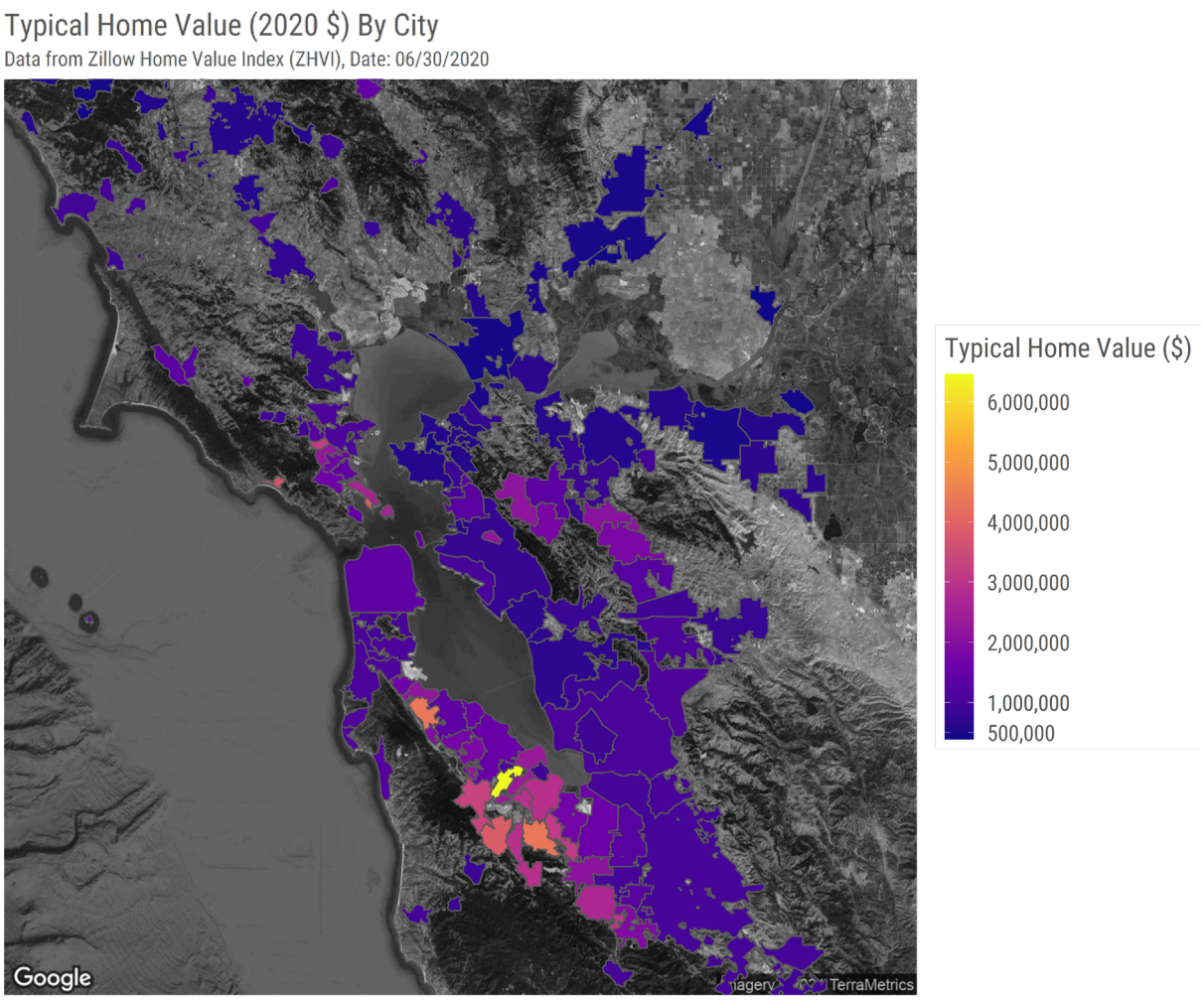

Figure 15. This map shows Zillow's Typical Home Value (ZTHV) for June of 2020 by city.

city and total household estimate from the American Community Survey (ACS) has the region at a total of $2.86 trillion in property value. Based on this San Francisco case study, many Bay Area communities with substantial property values – with the notable exception of disadvantaged communities – have available funding tools to pay for some of the needed resilience improvements of community-wide significance in their jurisdictions.

Regional Funding Totals using SCO Data

According to the SCO data, the annual averages between 2017 to 2019 for total expenditures on capital outlay and debt service for the 101 cities in the Bay Area (excluding any non-incorporated areas[1]) is about $2.5 billion. If we assume, hypothetically, that 1%-5% of regional spending could be reallocated or newly generated for adaptation funding, that leaves the region with about $25 million to $125 million each year for SLR adaptation. This is a rough magnitude of scale estimating what the region could expect for funding outside of any state or federal grants.

In addition to cities, there are 542 Special Districts in the region that spent an average total of about $870

1 It is important to note that there are 118 Census-designated Places in the Bay Area

million per year on capital outlay and debt service in the 2017 and 2019 fiscal years. Following the hypothetical 1%-5% reallocated spending from the example above adds an additional $8.7 million to $43.5 million annually for SLR adaptation.

On a county-level (excluding San Francisco, as it's expenditures are already covered in city expenditures, as it is both a city and a county) the SCO data indicates an expenditure on capital outlay and debt service of about $920.8 million per year. 1-5% of that spending would amount to $9.2 million – to $46 million for potential adaptation spending.

Total average annual revenue coming into the Bay Area's cities from the state and Federal Government between 2017 and 2019 is about $1.36 billion from the State of California and about $720 million from the Federal Government. Following the same order of magnitude hypothetical of assuming 1%-5% for reallocated spending adds an additional $13.6 million to $68 million from the State of California and $7.2 million to $36 million from the Federal Government annually for SLR adaptation.

By combining all of these sources, as shown in Table 8, a hypothetical $63.7 million to $318.5 million per year for SLR adaptation in the region could be made available if cities, Special Districts, California, and the Federal Government were able to allocate one to five percent of their spending to tackling sea level rise.

For comparison, MTC/ABAG estimates an existing sea level rise adaptation revenue of $3 billion for protection against shoreline flooding over the next 30 years (2020-2050) from sources such as FEMA, USACE, state bonds, local taxes and project funding.[1] This equates to $100 million per year and is within the estimate range we calculated above.

BART System Case Study: How the Region Funded Critical Infrastructure and Upgrades

"The initial three-county, voter-approved Bay Area Rapid Transit System (BART) in 1962 was projected to cost $996 million, or $7.1 billion inflated to 2016. Funding came from a combination of property taxes, bridge tolls, and fare revenues. This funding was used to support general obligation and revenue bond financing for initial construction of the system. Since 1996, the Bay Area Toll Authority has been implementing a $9.4 billion retrofit of the area's major bridges funded largely by bridge tolls."[2]

Initial construction projection: $8.3 billion in 2020 US dollars

Retrofit: $10.1 billion in 2020 US dollars

1 MTC/ABAG, "Plan Bay Area 2050", https://www.planbayarea.org/sites/default/files/documents/Plan_Bay_Area_2050_October_2021.pdf

2 NHA Advisors, "Finance Guide for Resilient by Design Bay Area Challenge Design Teams."

Table 8. Possible Back-of-the-Envelope, Magnitude of Scale Annual Revenue/Expenditure Forecast for SLR Spending in the Bay Area.

Bay Area Revenue Stream*	**Low (1%)**	**High (5%)**
City Expenditures	$25 million	$125 million
Special District Expenditures	$8.7 million	$43.5 million
County Expenditures	$9.2 million	$46 million
State Revenue	$13.6 million	$68 million
Federal Revenue	$7.2 million	$36 million
Total	**$63.7 million**	**$318.5 million**

** based on a percentage of existing revenue/expenditures from each source*

Funding & Financing Unknowns

Timing and Availability of Federal Funding Programs

Federal emergency funds are typically released in response to one-time disaster declarations, so the federal fiscal response to an ongoing, slow-moving disaster is unknown. Damages will hit the entire U.S. coast and the world simultaneously, so the question remains how the distribution of funds to states and regions will be affected on a national level. If everyone is experiencing a slow-moving crisis at once, it leads to a huge unknown of how national budgets will be able to accommodate all of the need.

Low-Capacity Cities

Lower-income communities with lower tax revenues do not have the resources for adaptation compared to places such as Silicon Valley with high tax revenues from properties and major corporations. Additionally, any financing mechanisms would be regressive, hitting lower income residents the hardest. Without a regional funding strategy advocating for directing funds to high-need, low-capacity jurisdictions, lower-income neighborhoods will be left behind without the resources needed to adequately protect neighborhoods. This would expose already vulnerable communities to even more environmental injustices beyond what they already face, as many low-income neighborhoods are located adjacent to hazardous waste sites.

Changes to Existing State Propositions

Prop. 26 requires a supermajority requirement for new taxes and fees. This makes any new funding measures very hard to approve without proper public engagement.

Prop. 218 was a constitutional amendment that protects taxpayers by limiting the methods by which local governments can create or increase taxes, fees, and charges without taxpayer consent. This heavily limited the funding for flood and stormwater utilities. While SB-231 sought to clarify the law, ongoing challenges mean that its future is uncertain.

Prop. 13 limits property tax to no more than 1% of the house's value in 1975 and limits annual increases to inflation or 2%, whichever is lower. It also requires a two-thirds majority vote of the state legislature to increase non-property taxes and a two-thirds majority vote for local governments for any special taxes. However, there have been significant efforts to reform this proposition as it is widely seen as stymieing revenue statewide. Proposition 15 in 2020 proposed changes to the bill that would have removed commercial properties from Prop 13's limits, but it did not pass. However, it is likely that future efforts will continue to seek reform, which could mean a changed landscape for municipal funding.

Population and Economic Growth

Population in the Bay Area and the economy are expected to continue to grow, which will have impacts on public revenue streams over time and change where and which adaptation strategies are required. More research is needed to include these two factors in revenue predictions.

Flood Insurance Rate Changes

The cost of FEMA and private flood insurance depend on the risk of flooding, which will increase as SLR continues and decrease as adaptation projects are put in place. Risk reduction through adaptation effectively reduces the overall public cost of adaptation projects.

Budget Changes due to Natural Disasters

The state and federal budgets and their availability for SLR resilience have been fluctuation a lot in the recent years due to the ongoing COVID-19 pandemic as well as wildfires.

Funding Gap: Bridging the Gap Between Funding Need and Supply

We can use the range of estimated costs of sea level rise adaptation and the one to five percent of projected regional revenue from the two previous sections to calculate the potential funding gap, assuming a constant, unchanged funding stream. Here, we are using a 30- to 80-year funding period, which corresponds to the high-risk aversion in OPC's California State guidance on the estimated occurrence of 3.3 to 6.6 feet of sea level rise on top of the average high tide (or mean higher high water, MHHW). That equates to 3.3 feet of SLR by 2050 and 6.6 feet of SLR by 2100.

The total funding need ranges from $19 billion to

Table 9. Estimated Annual Revenue Needs for SLR Adaptation Spending in the Bay Area.

Category	Definition	2 Feet of SLR by 2050 (30-year Funding Period)	6.6 Feet of SLR by 2100 (80-year Funding Period)
Potential **Total Annual Need** for the Region	Estimates of Total Annual Adaptation Costs for the Region	$633 million	$1,825 million
Potential **Total Existing Annual Funding** for the Region	1%-5%* of Total City and Special District Expenditures & State and Federal Revenue	$63.7 million - $318.5 million	$63.7 million - $318.5 million
Potential **Total Annual Funding Gap** for the Region	Additional Annual Funding Needed for the Region	**$315 million – $570 million**	**$1,507 million –$1,761 million**

The Total Annual Funding Gap can be expressed as:

% Bay Area GDP Annual Funding Gap	0.05% – 0.1%	0.25% – 0.3%
Per Capita Annual Funding Gap	$41 - $74	$196 - $229
Per Household Annual Funding Gap	$117 - $211	$558 - $652
Per Parcel Annual Funding Gap	$166 – $300	$793 – $927

Potential

**Theoretical range of current expenditure and revenues that could be made available for adaptation projects based on cities' capital outlay and debt service expenditures between 2017 and 2019.*

adapt to 2 ft of SLR (MTC/ABAG), $40 billion to adapt to 3.3 ft SLR, and $146 billion to adapt to 6.6 ft of SLR (UC Berkeley). Table 8 breaks these totals into annual spending using the 30-year and 80-year funding period for adapting to 2 feet and 6.6 feet of SLR, respectively.

The potential total revenue for the region over 30 years is $1.9 billion to $9.5 billion, using an annual revenue of $63.7 million to $318.5 million. This uses the same one to five percent estimate outlined in the previous section. Using this same process, potential revenue over 80 years is $5 billion to $25.5 billion.

This leaves a funding gap for the region is **$9.5 - 17.1 billion for 2 feet of SLR over 30 years** and **$120.5 - $141 billion for 6.6 feet of SLR over 80 years.**

For illustration purposes, this funding gap can be broken down into metrics such as per capita, per household, per parcel or as a percentage of GDP.

The 9-County Bay Area has:

- 7.7 million people live in the Bay Area
- 2.7 million households
- 1.9 million parcels
- $597 billion (2020 USD) GDP[1]

While this gap can seem daunting, comparing adaptation funding needs to the total property value in the Bay Area, $2.863 trillion, the funding gap above seems a lot more manageable --- 0.3 - 4.9% of total current property values. However, given the limitations on raising property taxes or any new taxes above, as well as competing demands and extremely high housing prices, it is difficult to raise these revenues.

1 statista, https://www.statista.com/statistics/183843/gdp-of-the-san-francisco-bay-area/

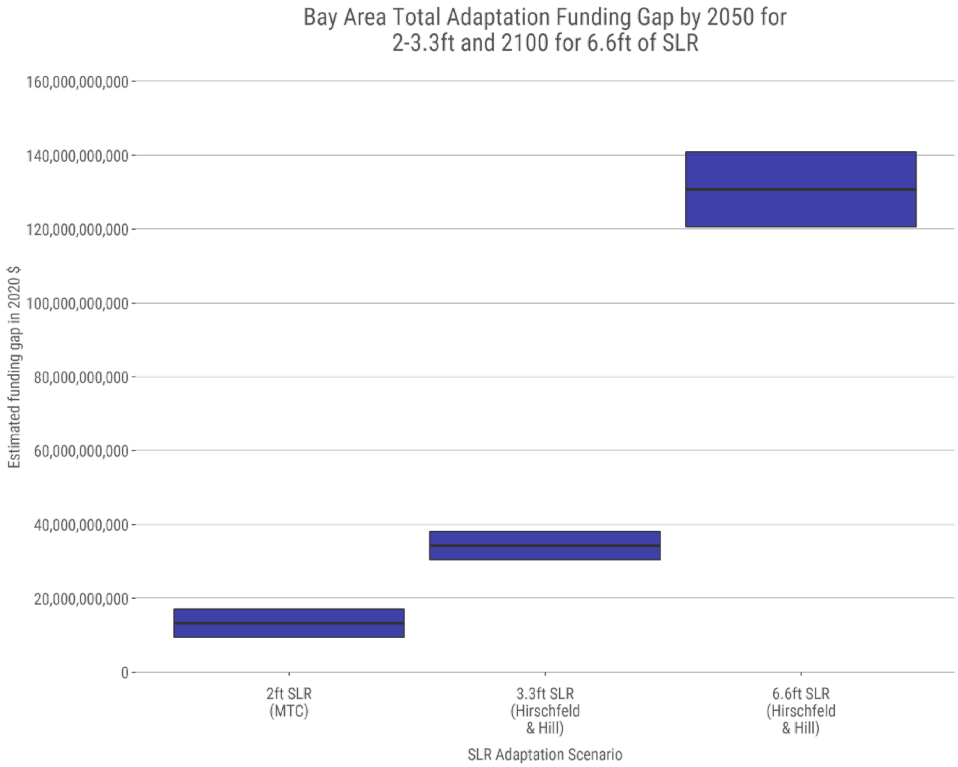

Figure 16. Estimated funding gap for SLR adaptation based on 1-5% of average public funding in the 9-County Bay Area in 2017-2019, including a side-by-side comparison of a 30-year funding timeline for 2-3.3ft of SLR and a 80 year funding timeline for 6.6. ft to match 2050 & 2100 SLR targets.

Funding Facts & Actions

While it is not possible to accurately estimate total Bay Area sea level rise adaptation needs at this juncture, policymakers at the State and Federal level are beginning to act to address the funding need. Fully-loaded regional adaptation needs to adapt to 2100 water levels will almost certainly exceed $100 billion; the window to act to protect our wetlands in the Bay is already closing.

As legislators begin to formulate funding solutions to match the new local funding sources that will also be required, the following proposed funding facts and actions should be put forward:

Equity

- Disadvantaged communities are not treated fairly by many current funding formulas
- Eliminate matching requirements for adaptation funding for disadvantaged communities
- Eliminate strict economic benefit-cost analysis as the primary driver for awarding adaptation funding because this approach favors areas with high pre-existing investment
- Create priority funding (formulas, pots, points) for defined disadvantaged communities such as MTC Communities of Concern
- Along with funding, provide proactive technical assistance to disadvantaged communities without the resources to apply for and execute risk assessment, adaptation planning and implementation.
- San Francisco Bay represents approximately 50% of the State of California's coastline[1] and almost 40% of the State's water supply drains to the Bay[2]; statewide adaptation funding should be allocated accordingly.
- Given the lack of storm-driven flood damage on the West Coast, most local communities are only starting to assess adaptation needs. With the rate of expected sea level rise, many local communities could wait too long to commence aggressive assessment and planning activities.
- Develop new adaptation funding streams with low matching requirements to encourage local communities and special districts to conduct rigorous, probabilistic multi-hazard risk assessments and conduct adaptation planning studies with a focus on delivering multi-benefit resilience projects to the public.

Nature-Based Adaptation and Science

- Prioritize funding for nature-based solutions, including preservation of wetlands.
- Fund additional study of how habitat can be improved in the near shore environment adjacent to human-made shorelines with deep water, including ports and airports
- Fund additional study of and pilot projects examining environmentally-sound practices for stormwater management as a companion to raising shorelines.
- Fund additional study of and pilot projects examining best practices for adapting urban/suburban wastewater facilities that discharge to the Bay.
- Fund assessment of policy barriers preventing effective funding and financing of nature-based solutions.

1 BCDC: https://bcdc.ca.gov/bay_estuary.html
2 USGS: https://ca.water.usgs.gov/projects/baydelta/studyarea.html

Adaptation Funding for Cities, Counties, Special Districts, Ports

Sea level rise adaptation is a newly identified need, so existing State and Federal funding sources to address this issue are not well-developed.

- Develop robust funding sources to encourage cities, counties, special districts and ports to design and implement coastal flood adaptation.
- Consider the role of private ownership of the coast, and mechanisms to encourage private investment in coastal flood protection with broader community benefits and/or mechanisms to encourage private property owners to allow the construction of coastal flood protection on their property.
- Consider the role of voluntary buy-out programs, land use changes, and managed retreat in urban areas. The technical analysis, strategic thinking, political coalition-building, community engagement, and planning required to advance this important work can be difficult to launch because it does not meet traditional grant criteria, to wit, it typically does not yield "shovel ready" projects, among other criteria.
- Further incentivize collaboration across agencies. Currently, for city agencies each tasked with a different core business and held accountable to ensure that no dollar is spent on non-core business, the disincentives for collaboration often outweigh the incentives. This situation grew out of a desire for good governance and financial stewardship, but has created a significant unintended consequence: a disincentive for integrated thinking, planning, project development, and project delivery. For integrated, advanced capital planning to occur, incentive structures need to change.

Discussion

Sea level rise will threaten coastal areas across the globe within this century and the Bay Area is no exception. Quantified economic damage estimates are still mostly limited to property damages and, in the U.S., linked to FEMA's flood insurance program and will certainly be significantly higher when accounting for social and ecological damages. Nevertheless, even when just looking at property damage, sea level rise is comparable to other national disasters, such as Superstorm Sandy and Hurricane Katrina (Figure 7). It is important to point out that unlike earthquakes and storms, sea level rise is permanent in nature and will exacerbate other flood events due to elevated tides and ground water levels. Yet, it is also incremental, which is an opportunity to prepare for and mitigate the worst impacts.

MTC/ABAG's Plan Bay Area 2050 estimates the cost of adapting to 2 feet of SLR, while protecting about 98% of households, to be around $19 billion. One academic study estimates the average costs of protecting the Bay Area to be $40 billion for 3.3 feet of SLR and $146 billion for 6.6 feet of SLR, highlighting the escalating increase in cost of raising shoreline protection structures to protect from higher sea level rise scenarios.[1]

The Bay Area's cities and special districts currently spend around $6.4 billion annually on capital outlay, debt service and of received state and federal grants. Using a hypothetical 1-5% of this total and allocating it for sea level rise adaptation would supply the Bay Area with about $1.9 billion to $9.6 billion for SLR adaptation over the next 30 years until 2050. This information allows us to start estimating the regional funding gap, which will exceed $10 billion, depending on the SLR scenario and employed adaptation strategies. Wealth and spending power vary greatly among Bay Area communities. If sea level rise is left to local governments to deal with by themselves, there will be significant gaps in the funding and ultimately construction of shoreline defenses, disproportionately affecting disadvantaged communities, threatening transportation networks, wetland habitats and other public services, such as wastewater treatment plants. Several initiatives like Bay Adapt, Plan Bay Area and BayCAN are working at different scales for potential solutions to sea level rise in the Bay Area, including funding. More work is needed to accurately estimate the cost and prioritize locations of adaptation projects that benefit the entire region.

A regional SLR adaptation funding strategy, as outlined in Bay Adapt, could greatly increase the region's ability to secure and distribute adaptation funds based on priorities laid out in a multi-stakeholder regional adaptation strategy. This paper seeks to lay the groundwork for such a plan and start to make the case for the region's funding needs.

1 Hirschfeld and Hill, "Choosing a Future Shoreline for the San Francisco Bay."

Appendix

Adaptation Project Profiles:

Foster City Levee Protection Planning and Improvements Project (CIP 301-657)
Shoreline Protection Type: Levee
Length: 34,717 feet
Flood Protection Level: 40"-42" of flooding from 100-year storm, FEMA accreditation
Cost: $90 million general obligation (GO) bond (Measure P voted in 2018).[1]

Hayward Regional Shoreline Master Plan
Shoreline Protection Type: Horizontal Levee
Length: not available in CHARG dataset
Flood Protection Level: 24"-48" of SLR + 40"-42" of flooding from 100-year storm
Cost: $440.9 million - $596.1 million (3 alternatives without contingency).[2]

Dumbarton Bridge West Approach + Adjacent Communities Resilience Study
Shoreline Protection Type: Levee
Length: 28,923 feet
Flood Protection Level: 36" of SLR + 40-42" of flooding from 100-y storm
Cost: $45.5 million - $1.8 billion (3-4 alternatives).[3]

SR-37 UC Davis (2100) Integrated Traffic, Infrastructure and Sea Level Rise Analysis
Shoreline Protection Type: Levee or Causeway
Length: 72,630 feet
Flood Protection Level: 36"-83" of SLR + 40"-42" of flooding from 100-year storm
Cost: $1.26 billion - $4.3 billion (3 alternatives).[4]

SR-37 Kimley-Horn (2050) Transportation and Sea Level Rise Corridor Improvement Plan
Shoreline Protection Type: Levee
Length: 72,630 feet
Flood Protection Level: Protect Highway from flooding until 2050, before highway is raised or reconstructed at higher elevation
Cost: $216.5 million to $439 million.[5]

South San Francisco Bay Shoreline Study (SSFBSS) Shoreline Report
Shoreline Protection Type: Levee
Length: 97,567/ feet
Flood Protection Level: 31" of SLR + 40"-42" of flooding from 100-year storm (15.2 feet levee height)
Cost: $174 million (alternative 3).[6]

Oro Loma Experimental Horizontal Levee
Shoreline Protection Type: Horizontal Levee
Length: not available in CHARG dataset
Flood Protection Level: No flood protection goal set
Cost: $9.1 million.[7]

Strategy to Advance Flood Protection, Ecosystems and Recreation along the San Francisco Bay (SAFER Bay) in East Palo Alto and Menlo Park
Shoreline Protection Type: Levee
Length: 16,884 feet
Flood Protection Level: 36" of SLR + 40"-42" of flooding from 100-year storm
Cost: $89.7 million - $104.9 million.[8]

1 "Levee Protection Planning and Improvements Project (CIP 301-657) | Foster City, California."
2 "Hayward Shoreline Masterplan."
3 "Dumbarton Bridge West Approach + Adjacent Communities Resilience Study Technical Report."
4 Shilling et al., "State Route 37 Integrated Traffic, Infrastructure and Sea Level Rise Analysis."
5 Kimley-Horn and Associates and AECOM, "SR 37 Transportation and Sea Level Rise Corridor Improvement Plan."
6 Santa Clara Valley Water District, "South San Francisco Bay Shoreline Phase I Study - Resolution Certifying the Final Environmental Impact Report and Adopting Findings of Fact, Statement of Overriding Considerations, and Mitigation Monitoring and Reporting Program; and Approving the Project."
7 Oro Loma Sanitary District, "Oro Loma and Castro Valley Sanitary Districts to Test Experimental Levee"; Save The Bay, "Oro Loma Horizontal Levee Vegetation Report."
8 San Francisquito Creek Joint Powers Authority, "Public Draft Feasibility Report SAFER Bay Project Strategy to Advance Flood Protection, Ecosystems and Recreation along San Francisco Bay East Palo Alto and Menlo Park."

The Port of San Francisco Embarcadero Seawall Program
Shoreline Protection Type: Seawall
Length: 16,505 feet
Flood Protection Level: Resilient waterfront over next 50 years
Cost: $5 billion.[1]

SFO Airport Shoreline Protection Project
Shoreline Protection Type: Steel Sheet/King Pile Wall
Length: 28,562 feet
Flood Protection Level: 36" of SLR + 40"-42" of flooding from 100-year storm
Cost: $587 million.[2]

Oakland Airport Capital Improvement Program
Shoreline Protection Type: Earthen Dike
Length: 25,223 feet
Flood Protection Level: Raise dike by 2 feet
Cost: $46 million.

1 San Francisco Port, "Embarcadero Seawall Program Overview."
2 "San Francisco Airport - Airport Shoreline Protection Project - Fiscal Feasibility Study."

Credits

- Nicolas Sander, Bay Area Conservation & Development Commission
- Samantha Cohen, Bay Area Conservation & Development Commission (former)
- Dana Brechwald, Bay Area Conservation & Development Commission
- Jessica Fain, Bay Area Conservation & Development Commission
- Larry Goldzband, Bay Area Conservation & Development Commission
- Brenda Goeden, Bay Area Conservation & Development Commission
- Jaclyn Perrin-Martinez, Bay Area Conservation & Development Commission
- Daniel Hossfeld, Bay Area Conservation & Development Commission
- Robert Spencer, Urban Economics
- Mark Northcross, NHA Advisors LLC
- Brad Benson, Port of San Francisco
- Sandra Hamlat, City and County of San Francisco
- Adam Varat, City and County of San Francisco
- Sarah Minick, San Francisco Public Utilities Commission
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- Jessica Ludy, U.S. Army Corps of Engineers
- Rachael Hartofelis, Association of Bay Area Governments & Metropolitan Transportation Commission
- Michael Germeraad, Association of Bay Area Governments & Metropolitan Transportation Commission